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# Lake Apopka Restoration Project, Lake and Orange Counties, Florida

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The action for which this document has been prepared is the restoration of Lake Apopka. The overall goal of the restoration project is to stop the continuing degradation of the lake's water and to restore Lake Apopka as a quality natural resource. Four primary objectives have been identified in attaining this goal. The first objective is to improve the water quality of Lake Apopka. Secondly, the project aims to improve water quality in the entire Upper Oklawaha Chain of Lakes by restoring the headwaters of this chain (Lake Apopka). The third objective is to provide aquatic habitats which are capable of supporting game fish and wildlife, with a subsequent reduction in rough fish. The final objective involves making Lake Apopka suitable for water-contact recreational opportunities.

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United States
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Region 4
345 Courtland Street, NE
Atlanta, GA 30308

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September 1979

PB80-151731

Clean Lakes

# Environmental Impact Statement

Final

# Lake Apopka Restoration Project Lake & Orange Counties Florida

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SPRINGFIELD, VA. 22161

Final Report

# FINAL ENVIRONMENTAL IMPACT STATEMENT

# FOR

# LAKE APOPKA RESTORATION PROJECT

# LAKE AND ORANGE COUNTIES, FLORIDA

Prepared By

U.S. Environmental Protection Agency
Region IV
Atlanta, Georgia 30308

With Technical Assistance By

Florida Department of Environmental Regulation
Bureau of Water Management
Water Resources Restoration and Preservation Section

RESPONSIBLE OFFICIAL

John C. White
John C. White
Regional Administrator

_______________
Date

SECTION 7 WRITTEN COMMENTS AND QUESTIONS ON THE DRAFT EIS AND EPA RESPONSES 61

Written Comments and Questions 62
Responses to Comments Received on Draft EIS 109

SECTION 8 PUBLIC HEARING ON THE DRAFT EIS 127

Transcript of Public Hearing 128
Responses to Comments and Questions 192

SECTION 9 LITERATURE CITED 197

APPENDIX A SEDIMENT CONSOLIDATION STUDIES A-1

APPENDIX B RSB&W ENGINEERING DESIGN B-1

Evaluation of Lake Restoration Impacts on Organic Soil Farms & Citrus Groves B-2
Proposed Facilities to Implement Plan B-15
Estimated Cost of Project B-55

APPENDIX C ALTERNATIVE RESTORATION PROPOSALS C-1

Aeration C-2
Hyacinths C-97
Sectioned Drawdown C-113
Dredging C-135
Annelidic Conversion C-155
Island Building C-161

TABLE OF CONTENTS

SUMMARY v

PREFACE xi

ERRATA SHEET xiii

SECTION 1 INTRODUCTION 1

Lake History 1
State and Federal Action 1
Citizen and Agency Concerns 3

SECTION 2 EXISTING CONDITIONS 5

Water Quality 5
Bottom Conditions 7

SECTION 3 ALTERNATIVES AND THEIR EFFECTS 13

No Action 13
Enhanced Fluctuation 17
Aeration 21
Dredging 22
Other Alternatives 28

SECTION 4 DESCRIPTION OF SELECTED ALTERNATIVE 29

Selection 29
Revised Engineering Design 29
Engineering Concerns 32
Biological and Chemical Concerns 35
Revised Recommendation 46

SECTION 5 IMPACTS OF PROPOSED ALTERNATIVE 55

Biological Impacts 55
Socioeconomic Impacts 57

SECTION 6 PUBLIC PARTICIPATION 59

## LIST OF TABLES AND FIGURES

| Table Number | Table | Page Number |
|---|---|---|
| 2.1 | Water Quality Data | 6 |
| 2.2 | Statistical Summary of Nitrogen and Phosphorus Concentrations in Sediments of the Oklawaha Lakes | 9 |
| 2.3 | Average Values of Leachable and Exchangeable Ammonium and Orthophosphate in Sediments of the Oklawaha Lakes | 9 |
| 3.1 | Nutrient Budgets for Lake Apopka | 14 |
| 4.1 | Sources of Refill Water at 65' MSL | 37 |
| 4.2 | Estimated Water Quality Under Various Conditions | 37 |
| 4.3 | Productivity of Vegetation Expected to Invade Lake Apopka During Drawdown | 39 |
| 4.4 | Lake Apopka Water Quality for Drawdown Stage Elevations | 42 |
| 4.5 | Estimated Removal Efficiency | 44 |

| Figure Number | Figure | Page Number |
|---|---|---|
| 2.1 | Turbidity, Ammonium, and Ortho-Phosphate Levels in Lake Apopka Over Time During Convective Storm on 23 September, 1978. | 11 |

# SUMMARY

# FINAL ENVIRONMENTAL IMPACT STATEMENT

# LAKE APOPKA RESTORATION PROJECT

The purpose of this final Environmental Impact Statement (EIS) is to meet the objectives of the National Environmental Policy Act (NEPA). NEPA directs federal agencies to prepare a statement which identifies all reasonable alternatives and which evaluates the environmental impacts of these alternatives. NEPA then directs federal decision makers to incorporate this environmental evaluation into the decision making process. This document has been prepared in accordance with these directives.

The action for which this document has been prepared is the restoration of Lake Apopka. The overall goal of the restoration project is to stop the continuing degradation of the lake's water and to restore Lake Apopka as a quality natural resource.

Four primary objectives have been identified in attaining this goal. The first objective is to improve the water quality of Lake Apopka to meet Class III standards as defined in Chapter 17-3, Florida Administrative Code. Secondly, the project aims to improve water quality in the entire Upper Oklawaha Chain of Lakes by restoring the headwaters of this chain (Lake Apopka). The third objective is to provide aquatic habitats which are capable of supporting game fish and wildlife, with a subsequent reduction in rough fish. The final objective involves making Lake Apopka suitable for water-contact recreational opportunities. These four objectives are the criteria by which the success of the restoration project will be judged.

Lake Apopka is a 12,500-hectare (31,000-acre) lake located in Central Florida, approximately 25 km (15 mi) northwest of Orlando. Although Apopka has a large surface area, it is a shallow lake, averaging less than 2 m (6.6 ft) in depth. Throughout the first half of this century Lake Apopka contained clear water and luxuriant vegetation and

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was noted for its excellent bass fishing. Today it is a highly eutrophic lake and experiences continual algal blooms. About 90 percent of the lake bottom is covered with organic deposits; in some places this muck is more than 15 m (50 ft) deep. These unconsolidated sediments are easily suspended in the water column, thereby causing extreme turbidity problems. Suitable habitats for game fish, rooted aquatic vegetation and benthic invertebrates have been reduced to fractions of their previous extent. Rough fish such as shad, gar, and catfish are now the dominant species in Lake Apopka.

Massive nutrient overloading is the main cause of Lake Apopka's demise as a quality resource. Sewage discharges from Winter Garden, irrigation water pumped from the muck farms, and citrus processing plant wastes were major contributors of nutrients. A 1947 hurricane uprooted much of the lake's vegetation, releasing more nutrients into the water, and was followed shortly thereafter by the lake's first algal bloom. Subsequent hyacinth spraying and selective rough fish poisonings added to the problem because the dead plants and fish were not removed from the lake. These operations, in conjunction with the lake level stabilization program begun in 1952, stifled any chance of a natural recovery of the lake's ecosystem.

Measures to improve water quality, restore the fisheries, and provide recreational opportunities have been outlined in this Final EIS. DER is the primary project sponsor and has contracted numerous studies through universities and other agencies to analyze specific problems related to the restoration project. Frost/freeze, hydrological, limnological, engineering, and legal studies have all been completed through DER contracts. Furthermore, the engineering firm of Ross, Saarinen, Bolton, and Wilder (RSB&W) was retained to study the feasibility and probability of success of the recommended long-term restoration action.

Numerous restoration alternatives were considered and analyzed in this Final EIS. The DEIS recommended a drastic drawdown of Lake Apopka. This would consolidate the muck and improve water quality. However, significant questions have been raised concerning the success potential of the drawdown alternative for Lake Apopka. Engineering concerns include dike protection, shoreline consolidation and irrigation systems. Biological and chemical concerns include water quality upon refill, invasion of the exposed bottom by terrestrial vegetation, sediment consolidation and nutrient release, and littoral zone expansion and game fish propagation. These questions are addressed in the Final EIS, but the responses are largely conjectural. Although drawdowns have been successful on other Florida lakes, the size of Lake Apopka, the severe time constraints imposed on the project schedule, and the characteristics of the muck layer make it difficult to predict the actual effects of the proposed drastic drawdown. In addition, the cost of a Lake Apopka drawdown has risen to $19.8 million. Because of the remaining uncertainties and the reduced cost effectiveness of the drawdown of Lake Apopka, a revised recommendation is proposed in the Final EIS.

Instead of an immediate drawdown, a phased restoration program using short-and long-term plans is recommended. The short-term plan includes continued monitoring of water quality in Lake Apopka and downstream lakes, and implementation of a test drawdown on Lake Mare Prairie, a smaller lake having characteristics similar to Lake Apopka. The monitoring will document the present condition of the upper Oklawaha lakes and any improvement in water quality after completion in 1980 of the waste abatement programs for Lake Apopka. The water quality parameters measured would be essentially those previously monitored by Brezonik et al (1978) and Tuschall et al (1979). The estimated cost of monitoring is $50,000. A test drawdown of Lake Mare Prairie would allow detailed examination of the drawdown concerns previously discussed and at a substantially lower cost ($70,000) than that of a Lake Apopka drawdown. With the data obtained from the test drawdown, a more accurate assessment of the effectiveness of a drastic drawdown for restoring Lake Apopka under design constraints can be made.

The long-term plan for lake restoration includes continued exploration of restoration alternatives and methods which would address the lake's internal nutrient loading problem. If, following the test drawdown, it is determined that drastic drawdown has a high probability of initiating recovery of the lake and the resulting benefits are expected to be significant and long-lasting, it will be recommended that the proposed drawdown be implemented. Two alternatives are suggested for the drawdown. First, the extreme drawdown as proposed by RSB&W could be implemented. However, it is essential that the studies on shoreline consolidation and the recommended geotechnical work and soil sampling be completed before the drawdown. The other alternative is to revise the current plan within the constraints set forth in the DEIS to improve the probability of success while minimizing adverse impacts. Unfortunately, this alternative is likely to increase project costs. If it is determined that a drastic drawdown is not feasible for Lake Apopka, the possibility of dredging the lake and marketing the muck as a useful product should be pursued and perfected. Currently, no market for the muck has been identified. In addition, significant environmental problems must be overcome before dredging can be implemented. If the dredging alternative cannot be perfected, and the drawdown cannot be implemented, the "no action" alternative is the only remaining practical recommendation. Enhanced fluctuation and nutrient abatement are important secondary lake improvement techniques and should be implemented regardless of the final restoration action.

The following impacts can be expected when the revised recommendation is implemented.

Adverse Impacts of Short-Term Plan

1. Algal blooms and unaesthetic conditions are expected to continue.
2. No immediate improvement in game fish populations is expected.
3. Recreation will continue at low levels.

Adverse Impacts of Long-term Plan

1. If drawdown becomes the long-term plan then the adverse impacts listed in the DEIS may be realized.
2. If some other alternative becomes the recommended plan,

then its adverse impacts will have to be delineated prior to implementation.

## Beneficial Effects of the Short-term Plan

1. It will be possible to document whether water quality improves due to the pollution abatement measures and natural recovery processes.
2. Time will be available for further study of the problems associated with a drawdown and for development of technology to make dredging of Lake Apopka cost effective.
3. An in-depth study of the test drawdown will provide valuable information needed to assess future drawdowns of Florida lakes.
4. Water quality in Lake Mare Prairie is expected to improve following the test drawdown.

## Beneficial Effects of the Long-term Plan

1. If the long-term plan is implementation of drawdown, then the beneficial effects listed in the DEIS will be expected.
2. If an alternative lake restoration technique eventually becomes the long-term plan, the specific benefits would have to be re-assessed.

# PREFACE

In early March of 1979, the Environmental Protection Agency (EPA), published and distributed a Draft Environmental Impact Statement (DEIS) on the Lake Apopka Restoration Project. This DEIS was written pursuant to the National Environmental Policy Act of 1969 and was prepared jointly by EPA and the Florida Department of Environmental Regulation (DER). The DEIS was filed with the Office of Federal Activities and was circulated to the appropriate federal and state agencies for comment and review. Local governmental agencies and interested individuals also received copies of the DEIS.

This Final EIS consists primarily of changes and revisions to the DEIS. Most of these revisions resulted directly from input by commenting agencies and individuals. This reflects favorably on the successful public participation program associated with the project. Other significant changes were the result of a revised engineering design of the proposed restoration technique. These changes evolved during the final engineering design phase subsequent to the printing of the DEIS.

The basic recommendation outlined in the DEIS is a drastic drawdown of Lake Apopka over a nine month period to consolidate the lake's muck bottom and enhance the growth of desirable aquatic vegetation. This recommended technique continues to be supported in the Final EIS, but further attention has been directed towards technical questions which were raised concerning the success potential of the proposed drawdown. Most of these questions are legitimate concerns and have been addressed to the fullest possible extent in this document. This Final EIS also recommends several studies which should be completed prior to implementation of the proposed drawdown. These studies would result in a better understanding of the actual results of a drastic drawdown and would improve the accuracy of the economic and environmental evaluation of such a large-scale restoration technique.

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Rather than a reprinting of the entire DEIS, the Final EIS consists only of changes and additions to the draft document and responses to comments received by EPA. This format was adopted to save publication costs and to more concisely present the additional information which has become available since the distribution of the DEIS. Therefore, the Final EIS should be read in conjunction with the DEIS to obtain a holistic view of Lake Apopka's history and the restoration project.

A brief synopsis of the lake's condition and the conclusions and recommendations of the EIS process are contained in the Summary of the Final EIS. This is followed by Section 1, the Introduction, which explains the lake's background, identifies citizen concerns, and outlines project objectives. Section 2 relates to existing conditions which were not addressed in the DEIS, and Section 3 analyzes various restoration alternatives. A description of the recommended alternative and associated impacts are described in the next two sections. The public participation program is addressed in Section 6, and the Final EIS concludes with a listing of all comments received and responses to each individual comment. A public hearing was held in Tavares on April 10, 1979, to present the proposed drawdown design to concerned citizens and to receive comments and input on the project in general. A copy of the transcript of this hearing is included in Section 8 along with responses to comments and questions raised at the hearing.

Any person receiving a copy of this Final EIS who does not have access to the DEIS may obtain a copy by writing to:

Environmental Protection Agency
EIS Branch
345 Courtland Street, N.E.
Atlanta, Georgia 30308

ERRATA SHEET FOR DRAFT EIS

| Page | Paragraph and Line | Correction |
|---|---|---|
| viii | Paragraph 4, line 2 | Change "avoid any" to "minimize" |
| x | Paragraph 2, line 8 | Change "enhancing lake ecosystems" to "enhancing the lake ecosystem" |
| 1 | Paragraph 2, line 4 | Change "51" to "48" |
| 30 | Paragraph 3, lines 2-5 | Change sentence to read "The hypothetical net input of water to Lake Apopka, if the flow of water out of the lake were blocked by a cofferdam, is easily computed by the formula: Hypothetical net input with cofferdam in place = actual outflow through Apopka-Beauclair Canal plus any increase in lake storage minus any decrease in lake storage." |
| 31 | Paragraph 1, lines 1-3 | Change title of Table 2.2 to read "Mean Monthly Hypothetical Net Input to Lake Apopka with Cofferdam in Place Between 1959 and 1976." |
| 32 | Paragraph 1, lines 1-3 | Change title of Table 2.3 to read "Yearly Hypothetical Net Input to Lake Apopka with Cofferdam in Place Between 1959 and 1976." |
| 87 | Paragraph 2, line 4 | Delete "primary" |
| 91 | Paragraph 1, line 2 | Delete "primary" |

| | | |
|---|---|---|
| 102 | Paragraph 2, line 2 | Change "19.6" to 19.2" |
| | Paragraph 2, line 3 | Change "(64 ft)" to "(63.0 ft)" |
| | | Change "19.6" to "19.2" |
| | | Change "17%" to "13%" |
| | Paragraph 3, line 1 | Change "17%" to "13%" |
| | | Change "10,400" to "10,900" |
| 163 | Paragraph 3, line 1 | Change "eliminate" to "minimize" |

CLEAN-FLO LABORATORIES, INC.

4342 SHADY OAK ROAD HOPKINS, MINNESOTA 55343

December 22, 1978

Ms. Jean Tolman
Office of Water Resources
Florida Department of Environmental Regulation
2600 Blair Stone Road
Tallahassee, Florida 32301

Dear Ms. Tolman:

Clean-Flo Laboratories, Inc. has reviewed the information which was made available to us on Lake Apopka, and accordingly, we are submitting the enclosed analysis and restoration proposal.

In studying the available information, we have attempted to define the problems in Lake Apopka, the causes of the problems, and the desired goals.

We believe that the major problem in Lake Apopka is that it will not support any meaningful sport fish activity. We believe this because prior to 1946, the lake was famous for its bass fishing. Other than this, the lake has served as a receptacle for waste effluent from the City of Winter Garden since 1922, and citrus processing wastes since 1946; and as a source of organic soil, water, and fertilizer for the vegetable farms (muck farms) since 1943.

In 1962, it was estimated that an acre-foot of water used for fishing and related activities adds $200 to $300 to the economy of a state, while an acre-foot of water used by agriculture adds only $50 (Wollman, et al, 1962). Restoration plans, therefore, must be for the major purpose of returning good fishing to the lake. The other uses could proceed with the lake in its present condition, and it would make an ideal symbiosis.

If the above assumption is correct, the cause of the problem can be identified as a massive influx of nutrients. A study of the Vollenweider phosphorus loading model for Lake Apopka (Vollenweider, 1969 and 1976) shows that for the lake to be returned to a mesotrophic state would require a reduction of phosphorus input of 82 - 99%; approximately 91%.

Phosphorus released by bottom sediment during anaerobic periods is about 9% of the total incoming load, so we feel that removing the sediment completely would not appreciably alter the hypereutrophic level of the lake.

S-1

Drawdown has been very successful in consolidating sediment, improving water quality, and improving fishing in several lakes. Nevertheless, the data studied indicated that Lake Apopka has different characteristics that should be seriously considered. Fox, et al, (1977) on pages 77 - 79 show that drying of Lake Apopka sediment test samples followed by refill did not improve water quality. They wrote, "Too little drying stimulates nitrate release and more seriously will not consolidate the sediments and stabilize the interface. On the other hand extensive drying tends to release more ammonia and phosphate, at least in short term tests, than does undried sediment". Therefore, it does not appear likely that drawdown of Lake Apopka will affect water quality.

Unless water quality is improved, it should be assumed that hydrogen sulfide, ammonia, and carbon dioxide gases will remain at levels toxic to fish and benthic organisms, and that periodic oxygen depletions will continue to occur.

A secondary goal in lake restoration may be to compact or remove the bottom sediment. Although sedimentation rate is not available, it could be that without compaction or removal the lake will ultimately fill completely and become a massive marsh area. Yet, upon investigation of Fox et al, 1977, the graph on page 31 shows that drying a 30-inch column of Lake Apopka sediment will reduce it only 3 inches. Draining the bottom of the sediment compacted the column by 8 inches, but this would not be feasible in the lake itself.

In view of the above data, the proposed dewatering of Lake Apopka will only delay the need for costly dredging. Unless the nutrient loading is reduced to unapproachably low levels, sedimentation will continue at or near its present rate. Drawdown plans then, should include a study of sedimentation rate, including plans for repeated drawdowns, and an estimation of when the lake will ultimately be filled.

Germination tests and the Vollenweider loading model indicate that following drawdown, it is to be expected that exposing the sediment to sunlight will cause the lake to fill with emergent plants around the littoral regions, with either water hyacinth or submergent plants throughout the remainder of the lake, whichever becomes established first. Because of the nutrient load, massive plant growth can be expected.

It would seem then, that plans for drawdown should include a herbicidal treatment program.

Downstream nutrient enrichment, citrus grove temperature stability, and effect on fish, birds, and alligators, were felt by previous investigators to not be serious factors. However, the affect of pumping high levels of pathogenic bacteria downstream (staphylococcus levels as high as 320,000/100 ml) should be carefully evaluated.

Clean-Flo Laboratories, Inc. has restored many lakes that would not support game fish. At the same time, organic sediment has been rapidly removed by conversion into the food web at a fraction of the cost of dredging. No harm has been done to the environment.

Lake Maggiore, in St. Petersburg, Florida is a prime example of a lake which was almost identical to Lake Apopka in every way except size. This 400-acre lake was 3.5 feet deep, with 4.5 feet of sediment under that, and no bass could be found, although the lake had been stocked with 800,000 black bass in the past. Water chemistry was similar, but worse than Lake Apopka. No submergent plants were found, and a heavy blue-green algae growth prevailed, as in Apopka. Clean-Flo was hired to restore the lake, and after two years, Lake Maggiore is teaming with bass and fresh water shrimp, and over half the sediment is now gone. We feel that this type of in-lake restoration is also indicated for Lake Apopka.

Cost for the Clean-Flo program is $11,259,000 based on today's prices, compared to $13,900,000 for drawdown. Costs will increase at a rate of about 10% per year based on today's rate of inflation.

Please let me know of any questions you may have concering this proposal. Extra copies are available for anyone concerned, upon request.

Very truly yours,

Robert L. Laing

Robert L. Laing, President
CLEAN-FLO LABORATORIES, INC.

RLL:ak

cc: John Hagen
Leo Tebo
Al Burkhalter
Smokey Hokum
Governor Askew
Carlton Layne

# SECTION 1

# INTRODUCTION

## Lake History

Until the 1950's, Lake Apopka attracted national attention as a bass fishing lake. Lake Apopka now attracts state-wide attention as an example of the worst effects of cultural eutrophication. In less than a generation the lake has changed from a resource of high economic and aesthetic value into a problem requiring complex and expensive solutions. The DEIS explains in great detail the successive stages of Lake Apopka's degradation. The reader, therefore, is encouraged to refer to that document for a complete background on the lake's history and current status.

## State and Federal Action

During the past decade, a $9 million nutrient abatement program for Lake Apopka has been implemented and is nearly completed. An explanation of this program is included in the draft document, but basically abatement consists of three major actions:

1. An agricultural waste abatement program conducted by the muck farmers at a cost to them of approximately $1 million;
2. A citrus processing waste abatement program at a cost to the industry of about $3.5 million; and
3. A domestic waste abatement program for the City of Winter Garden implemented by constructing a sewage treatment plant at a total cost of nearly $4.5 million.

Although these actions have greatly reduced the nutrient input to Lake Apopka, additional restoration efforts are necessary to obtain a long-term improvement in the lake's water quality.

In 1976, the Florida DER accepted responsibility for an EPA Clean Lakes grant which had originally been awarded to the Florida Game and Freshwater Fish Commission (FG&FWFC). This grant was used to fund preliminary studies in the overall goal of restoring Lake Apopka. Although many reports and studies had already been completed, and drawdown appeared to be the most feasible restoration technique, noticeable gaps in information still existed when DER undertook the project. The following studies, therefore, were contracted by D.E.R.:

1. Frost/freeze study by the University of Florida;
2. Hydrological study by the U.S. Geological Survey;
3. Data updating by Bio-Engineering Services;
4. Study of the legal implications of drawdown by David Gluckman; and
5. Limnological study of the effects of drawdown by the University of Florida.

In the spring of 1978, EPA and DER mutually agreed to prepare an environmental impact statement. The EIS, therefore, was begun in May 1978, and revisited the entire question of the most effective method of restoring Lake Apopka. The alternatives considered included no action, enhanced fluctuation, chemical sedimentation, dredging, nutrient diversion, flushing, aeration, and drawdown. Of all these alternatives, only dredging and drawdown would directly address the problem of reducing nutrient releases from the highly flocculent muck bottom to the water column. Retarding or reducing this release was and still is considered essential to restoring Lake Apopka on a long-term basis.

Several of the other alternatives, such as nutrient diversion and enhanced fluctuation, were considered as secondary treatments, but dredging and drawdown were definitely most effective. Further analysis revealed that dredging would be prohibitively expensive for the 124 square kilometer (48 square mile) Lake Apopka. In addition, the disposal of an estimated 222 million cubic meters of muck spoils would be an overwhelming undertaking. Drawdown, on the other hand, has been implemented on other Florida lakes with varying degrees of success. Natural and man-induced drawdowns resulted in more extensive littoral zone vegetation, increased game fish populations, and improved lake bottom conditions (FG&FWFC, 1978b). Although drawdown is not free of detrimental side effects, the DEIS recommended it as the most feasible alternative for the restoration of Lake Apopka.

The engineering firm of Ross, Saarinen, Bolton, and Wilder (RSB&W) was contracted to perform the engineering design study for the proposed drawdown. Numerous constraints were imposed on the design from the beginning, most notably the requirement that the lake be at elevation 19.5 m (64 ft) msl during the winter months to provide frost/freeze protection for adjacent citrus groves. Other constraints required the protection of environmentally sensitive areas, minimal degradation of downstream waters, and the provision of irrigation water to nearby muck farms and citrus groves.

A detailed description of the preliminary drawdown design as envisioned by RSB&W is contained in Appendix B of the DEIS. Adverse impacts of the proposed drawdown were also discussed as well as measures to mitigate such impacts. This analysis constitutes the most important section of the DEIS. Final design of the proposed drawdown is included in Appendix B of this document, and further recommendations are made as to the optimal method of restoring the lake.

## Citizen and Agency Concerns

During the early stages of the drawdown design and analysis of environmental impacts, most citizens were highly in favor of the project. A list of initial citizen concerns was identified by DER and local officials, and these concerns were addressed both in the DEIS and in RSB&W's engineering design. As the impact statement assessment and engineering design continued, however, citizen support of the proposed project began to waver.

The vast majority of citizens still favor restoring Lake Apopka, but many concerns have been raised over the side effects of the proposed drawdown project. Downstream owners worry about their property being flooded, lakeside residents are unsure of the effects of consolidation on their property, and citrus grove owners fear that the decrease in the amount of frost/freeze protection afforded by the lowered lake will be significant.

Some state and local agencies have also raised questions about several technical aspects of the proposed drastic drawdown. Specific concerns relate to the quality of refill water, nutrient release rates from decomposition of invading terrestrial vegetation, distribution and spreading of unconsolidated bottom sediments, and successful establishment of aquatic macrophytes upon refilling the lake. All of these issues have been addressed to various degrees in the DEIS, but recent additional information necessitates further analysis of the situation in this Final EIS.

Finally, and possibly most importantly, the cost of implementing the drawdown has increased substantially since the preliminary engineering design phase. Because of problems with soil stability, changes in irrigation systems, and other alterations in engineering facilities to meet project constraints, the original $13.9 million cost estimate has increased to $19.8 million. Thus, the cost effectiveness of the proposed project has suffered a significant setback and must be re-examined in light of this new situation.

Although it is realized that the cost of the proposed project will continue to rise as further delays occur, the restoration should be accomplished in the most cost effective manner possible, both environmentally and economically. Further analysis, therefore, is warranted in this situation so that a better understanding of the actual effects of the project can be more accurately ascertained.

# SECTION 2
# EXISTING CONDITIONS

## Water Quality

Since preparation of the DEIS, DER has received water quality data from the Department of Environmental Engineering Sciences, University of Florida (Brezonik et al, 1978; Tuschall et al, 1979). The University of Florida was contracted by DER in March, 1977, to monitor the water quality of the Oklawaha chain of lakes in order to obtain water quality data prior to the proposed drawdown. These data will be used for comparative purposes during and subsequent to the proposed drawdown to assess its effects on water quality. A summary of the results of this monitoring program (see Table 2.1) are presented here to update the DEIS.

An examination of the water quality data presented in the DEIS led to the suggestion that the Oklawaha chain of lakes could be considered in three groups. The data presented in Brezonik et al (1978) and Tuschall et al (1979) confirm these groupings:

1. The Lake Harris, Little Lake Harris, and Lake Yale group generally have better water quality than the other lakes in the basin. This is probably because these lakes do not receive water from Lake Apopka. Historical water quality comparisons could not be made between the recent data and those that were obtained before 1977 because these lakes were not investigated by Brezonik et al (1978) and Tuschall et al (1979).

2. Lakes Griffin and Eustis form a second group with similar water quality. They are the most distant group in the chain of lakes receiving water from Lake Apopka and have better water quality than the upstream lakes. Historical comparisons with data prior to 1977 suggest that no substantial changes have occurred in 1977 and 1978. Dissolved oxygen, total organic nitrogen, ammonia, inorganic nitrogen, phosphorus, and chlorophyll-a values were all within the ranges of values found previous to 1977. In addition, water transparency was better and

Table 2.1 Water Quality Data[1]

| | pH | Dissolved Oxygen mg $l^{-1}$ | Organic Nitrogen mg $l^{-1}$ | $NH_3$-N mg $l^{-1}$ | Inorganic Nitrogen mg $l^{-1}$ | Total P mg $l^{-1}$ | Ortho-P mg $l^{-1}$ | Chlorophyll-a ug $l^{-1}$ |
|---|---|---|---|---|---|---|---|---|
| Lake Apopka | | | | | | | | |
| 1973-1976 | 7.2-9.5 | 6-12 | 2.7-5.7 | .01-.24 | .01-.3 | .07-.3 | .01-.06 | 18 |
| 1973 $\bar{x}$ | 9.22 | 9.5 | 3.2 | .12 | .26 | .117 | .022 | 47 |
| 1977 $\bar{x}$ | 8.87 | 10.9 | 3.4 | .04 | .09 | .221 | .047 | 33 |
| 1978 $\bar{x}$ | 8.41 | 11.5 | 4.7 | .06 | .11 | .156 | .039 | 51 |
| Beauclair | | | | | | | | |
| 1973 $\bar{x}$ | 9.15 | 10.2 | 3.68 | .225 | .098 | .041 | | |
| 1977 $\bar{x}$ | 8.73 | 11.0 | 3.4 | .089 | .33 | .230 | .020 | |
| 1978 $\bar{x}$ | 8.56 | 12.0 | 4.3 | .110 | .12 | .217 | .058 | 70 |
| | | | | | | | .034 | 150 |
| Dora | | | | | | | | |
| 1973 $\bar{x}$ | 9.29 | 10.2 | 3.0 | .112 | .116 | .095 | .025 | 60 |
| 1977 $\bar{x}$ | 8.69 | 10.2 | 3.0 | .135 | .19 | .160 | .049 | 68 |
| 1978 $\bar{x}$ | 8.47 | 11.1 | 3.4 | .120 | .23 | .110 | .020 | 67 |
| Eustis | | | | | | | | |
| 1973 $\bar{x}$ | 8.66 | 9.6 | 3.4 | .112 | .12 | .112 | .020 | |
| 1977 $\bar{x}$ | 8.62 | 10.1 | 2.7 | .044 | .08 | .133 | .022 | 23 |
| 1978 $\bar{x}$ | 8.33 | 10.1 | 2.5 | .076 | .10 | .075 | .017 | 32 |
| Griffin | | | | | | | | |
| 1973 $\bar{x}$ | 8.72 | 8.4 | 2.2 | .144 | .112 | .184 | .033 | 66 |
| 1977 $\bar{x}$ | 8.51 | 9.7 | 2.4 | .038 | .11 | .143 | .027 | |
| 1978 $\bar{x}$ | 8.15 | 10.1 | 2.5 | .06 | .11 | .092 | .022 | 55 |

[1] 1973 data from STORET; 1977 data from Brezonik et al, 1978; 1978 data from Tuschall et al, 1979.

specific conductivity, turbidity, and total organic carbon were lower in Lake Eustis and Lake Griffin than in upstream lakes.

3. Lakes Apopka, Beauclair, Carlton, and Dora exhibit the poorest water quality of the lakes in the upper Oklawaha River Basin. Dissolved oxygen levels are frequently supersaturated and pH levels often exceed the upper standard of 8.5 for Class III waters. These conditions result directly from excessive phytoplankton growth. Historical comparisons of recent data with pre-1977 data suggest that no significant changes have occurred in dissolved oxygen, total organic nitrogen, ammonia, inorganic nitrogen and phosphorus. Chlorophyll-a concentrations were also found to be within previous ranges for all of the lakes except Lake Beauclair where a higher concentration was found in 1978 than in previous years. These lakes, as a group, are the most eutrophic of the Oklawaha lakes and have the highest turbidity and specific conductivity of any group of lakes.

Several trends in water quality were evident from the analysis of the 1977-1978 annual mean parameter values. Total phosphorus, orthophosphorus, and pH decreased in 1978 in all of the lakes. However, total organic nitrogen increased in all the lakes except Lake Eustis. In 1978, specific conductivity decreased in Lakes Apopka and Beauclair but increased in the other lakes. Also, there was a slightly higher concentration of chlorophyll-a in Lakes Apopka and Eustis and a significantly greater chlorophyll-a concentration in Lakes Beauclair and Griffin. No concrete explanation can be given for these recent changes in water quality parameters. Although it appears with respect to phosphorus that the lake system may be improving, a different conclusion may be drawn from the nitrogen and chlorophyll data.

## Bottom Conditions

Since preparation of the DEIS, DER has received data on the characteristics of the muck associated with Lake Apopka and other Oklawaha Lakes (Brezonik et al, 1978; Pollman and Brezonik, 1979). An understanding of the bottom conditions in these lakes is important in predicting future trends in water quality and in assessing the impacts of the proposed restoration alternatives. The muck on the bottom of these lakes can be described as loose and flocculent. It has a fairly uniform brown-black color and a relatively high water content. The muck covers approximately 90% of the bottom of Lake Apopka to an average thickness of 1.5 meters (5 feet). Only 5% of the lake bottom is suitable for the spawning of fish, the raising of fish food organisms, and the establishment of aquatic macrophytes.

Brezonik et al (1978) investigated the characteristics of the muck in the Oklawaha chain of lakes. The average water content of the sediment was high and ranged from 96% to 98% for all of the lakes except Lake Griffin (92.8%). The average volatile solids content of the sediment, which is an indication of the organic content of the sediment, ranged from 55% to 63%. Lake Apopka sediments had the highest organic carbon content, while Lake Griffin sediments had the lowest. For comparative purposes, the volatile solids in sandy sediment are low and average about 0.3%.

Nutrients associated with the sediments and the interstitial water in these lakes were also investigated by Brezonik et al (1978). The mean total nitrogen content ranged from 21.1 to 27.2 mg/g dry weight sediment (Table 2.2.). The mean total phosphorus content of the sediment ranged between 0.53 and 1.45 mg/g dry weight sediment. Lake Dora sediments had the greatest amount of nitrogen and phosphorus; while Lake Griffin sediments had the least. These sediment nitrogen and phosphorus levels were high and are indicative of eutrophic conditions. The concentration of nutrients present in the interstitial water and the levels of nutrients leachable from the sediment are an estimate of the potential for nutrient release from the sediment. Interstitial and leachable ammonia values for Lake Apopka sediments (Table 2.3.) were similar to values obtained in other studies on eutrophic lakes; however, the concentrations of interstitial and leachable phosphorus were low and do not reflect the hypereutrophic status of the lake.

The shallowness of Lake Apopka makes it important to consider the effect of the sediment nutrient pool in the lake's nutrient budget.

Table 2.2. Statistical Summary of Nitrogen and Phosphorus Concentrations in Sediments of the Oklawaha Lakes.[1,2]

| | TKN | | TOTAL P | |
|---|---|---|---|---|
| Lake | $\bar{X}$ | S.D. | $\bar{X}$ | S.D. |
| Apopka | 26.8 | 4.0 | 1.02 | 0.54 |
| Beauclair | 26.8 | 2.7 | 0.89 | 0.23 |
| Dora | 27.2 | 4.3 | 1.45 | 0.43 |
| Eustis | 26.9 | 4.6 | 0.93 | 0.40 |
| Griffin | 21.1 | 10.2 | 0.53 | 0.29 |

[1] All concentrations in mg N or P/g (dry wt); $\bar{X}$ = average over all dates and all stations in each lake; S.D. = standard deviation over all dates and all stations in each lake.

[2] Source: Brezonik et al, 1978.

Table 2.3. Average Values of Leachable and Exchangeable Ammonium and Orthophosphate in Sediments of the Oklawaha Lakes.[2]

| | LEACHABLE | | EXCHANGEABLE | |
|---|---|---|---|---|
| | $NH_4^+$-N | Ortho-P | $NH_4^+$-N | Ortho-P |
| | mg N/g-dry wt | ug P/g-dry wt | mg N/g-dry wt | ug P/g-dry wt |
| Apopka | 0.47 | 13.8 | 1.07 | 44.4 |
| Beauclair | 1.58 | 101.0 | 1.83 | 237.0 |
| Dora[1] | 0.40 | 36.6 | 0.50 | 84.0 |
| Eustis | 0.83 | 10.0 | 1.51 | 42.9 |
| Griffin | 0.61 | 11.5 | 0.87 | 44.7 |

[1] Includes one sand station.

[2] Source: Brezonik et al, 1978.

Pollman and Brezonik (1979) investigated the exchange of nutrients between the bottom and the overlying water in Lake Apopka. They found two major mechanisms responsible for the exchange: diffusion and advection. Diffusion of nutrients out of the sediment and interstitial water occurs in response to concentration gradients. Using an equation developed by Berner (1971), Pollman and Brezonik (1979) calculated the potential diffusion of phosphorus to the overlying water to be 5.25 mg $P/m^2$-day. Advective turbulent release represents another mechanism by which nutrients are transported from the sediments to the overlying water. During the passing of storms, the interface between muck and the overlying water can be disturbed by wave action. This can lead to turbulent release of nutrients in Lake Apopka. High winds associated with a convective storm of September, 1978, brought about an immediate increase in turbidity and inorganic nutrient concentrations in the lake (Figure 2.1). The concentration of phosphorus released during this storm was estimated to be two times greater than the average annual mean phosphorus concentration for Lake Apopka. Furthermore, a total of 38,000 Kg of phosphorus are available for release by these two mechanisms. This represents a large reservoir of nutrients available for continued algal propagation in the lake.

Another characteristic of sediment important to the ecology of a lake is the amount of oxygen required for decomposition of organic matter in the sediment. High sediment oxygen demand can lead to anoxic conditions in bottom lake waters, which may result in damaging fish kills. Oxygen uptake by Lake Apopka sediments is primarily by bacterial decomposition. However, the oxygen demand is relatively low (about 70 mg $O_2/m^2$-hour) and suggests that much of the organic matter in Lake Apopka is decomposed in the water column as a result of wind mixing and resuspension. This supports Hargrave's (1973) views that during eutrophication, decomposition at the sediment interface is progressively replaced by decomposition and oxygen uptake in the water column.

The role of muck in Lake Apopka's future is of major concern. The sediment is presently a net sink for nutrients; however, the frequent wind-induced mixing and resuspension of the muck allows the release of large amounts of nutrients. Even with the completion of the wastewater

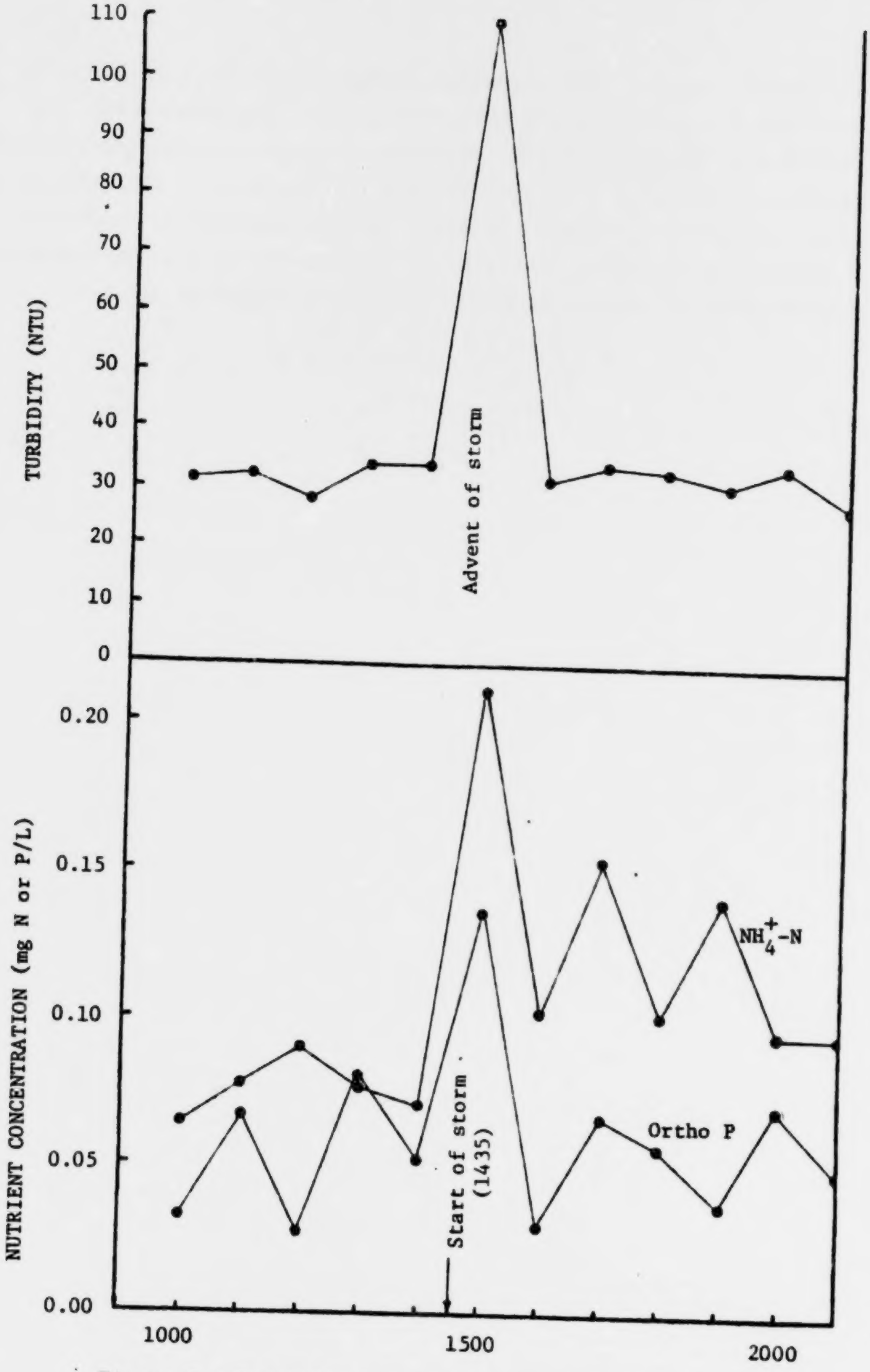

Figure 2.1. Turbidity, ammonium, and ortho-phosphate levels in Lake Apopka over time during convective rain storm on 23 September, 1978.

Source: Pollman & Brezonik, 1979

abatement programs, this turbulent release of nutrients is likely to continue for as long as the muck remains in a flocculent state. In addition to algal bloom problems associated with nutrient release, the mixing and suspension of the muck increases turbidity. This results in the reduction of the amount of light reaching the bottom, which discourages the growth of macrophytes. Macrophytes are also smothered by the movement of the flocculent muck along the bottom of the lake.

## SECTION 3

## ALTERNATIVES AND THEIR EFFECTS

### No Action

The No Action alternative may be an inexpensive, simple means of restoring Lake Apopka naturally. To determine the feasibility of this alternative, the nutrient budgets and trends in water quality of Lake Apopka and the downstream lakes were examined.

One of the contributing factors to the decline of Lake Apopka has been the addition of nutrients to the lake by cultural (man-made) sources. To help alleviate this problem, several nutrient abatement programs are currently being implemented. The Winter Garden Citrus Co-op has had an adequate waste treatment program for several years and currently releases only cooling water and small amounts of condensation by-products directly into the lake. The Winter Garden Advanced Wastewater Sewage Treatment Plant (STP) will be fully operational in 1979, entirely eliminating this source of nutrients to Lake Apopka. The muck farms on the north shore of Lake Apopka contribute significant amounts of nitrogen and phosphorus to Lake Apopka. The farms outside of Zellwood Drainage District #2 are scheduled to have operational waste treatment programs in 1979, which will reduce nutrient loadings by 65%. Inside Zellwood Drainage District #2, the waste treatment program will be complete by July, 1980. It will remove 50% of the suspended solids, 30% of the nitrogen and 25% of the phosphorus formerly pumped to Lake Apopka (see pages 39-45 the DEIS for more details).

Information on the input of nutrients to a lake is required before predictions can be made concerning its future water quality. Three nutrient budgets have been attempted for Lake Apopka. The former Florida Department of Pollution Control (DPC) published such a budget in 1972. However, compared to the subsequent budgets, nutrient values in the DPC budget are extremely high and should not be considered reliable. In 1977, EPA published a report of the National Eutrophication Survey (NES) that included a nutrient budget for Lake Apopka, using data from 1971 and 1973 (Table 3.1). This budget revealed that the muck farms were the major contributors of phosphorus (58%) followed by non-point sources (16%) and the Winter Garden STP (12%). The nutrient budget listed the non-point sources as the major contributor of nitrogen (45%) followed by the muck farms (30%) and precipitation (17%). It should be noted, however, that the non-point source category in the NES nutrient budget also includes contributions from tributaries draining the Winter Garden STP and the muck farms.

TABLE 3.1. NUTRIENT BUDGETS FOR LAKE APOPKA

1. NITROGEN

| | National Eutrophication Survey | | Brezonik et al 1978 | |
|---|---|---|---|---|
| | Kg | % | Kg | % |
| Precipitation | 72,730 | 17 | 159,400 | 35 |
| Gourd Neck Springs | --- | -- | 6,380 | 1 |
| Lateral Inflow | --- | -- | 23,370 | 5 |
| Septic Tank | 2,920 | 1 | ---- | -- |
| Winter Garden STP | 24,100 | 6 | 23,870 | 5 |
| Citrus Co-op | 5,960 | 2 | 4,600 | 1 |
| Muck Farms | 124,150 | 30 | 233,400 | 52 |
| Other Non-point runoff[1] | 187,870 | 45 | ---- | -- |
| TOTAL | 417,730 | | 451,000 | |

2. PHOSPHORUS

| | National Eutrophication Survey | | Brezonik et al 1978 | |
|---|---|---|---|---|
| | Kg | % | Kg | % |
| Precipitation | 5,520 | 7 | 6,322 | 11 |
| Gourd Neck Springs | --- | -- | 2,470 | 4 |
| Lateral Inflow | --- | -- | 1,690 | 3 |
| Septic Tank | 80 | 1 | --- | -- |
| Winter Garden STP | 9,645 | 12 | 7,090 | 13 |
| Citrus Co-op | 5,395 | 7 | 1,300 | 2 |
| Muck Farms | 45,870 | 58 | 36,886 | 66 |
| Other Non-point runoff[1] | 12,300 | 16 | --- | -- |
| TOTAL | 78,810 | | 55,750 | |

[1] Includes Muck Farm and Winter Garden STP Tributaries and Runoff. Brezonik et al (1978).

Brezonik et al (1978) also developed a nutrient budget for Lake Apopka using data collected in 1977 (Table 3.1.). They found the major contributors of phosphorus to be the muck farms (66%), the Winter Garden STP (13%) and precipitation (11%). The major contributors of nitrogen were the muck farms (52%), precipitation (35%) and the Winter Garden STP (5%). If the non-point source category is excluded, then the ranking of the contributors is the same for both the NES and the Brezonik et al (1978) budget. To summarize, muck farms, the Winter Garden STP, and precipitation are the principle sources of phosphorus, while muck farms, precipitation, and the Winter Garden STP are the major contributors of nitrogen.

Upon examination of the budgets, it becomes apparent that elimination of the cultural sources of nutrients should be a major objective in any lake restoration program for Lake Apopka. The Winter Garden STP contribution will be entirely eliminated in 1980. The muck farm contribution will also be decreased significantly by 1980. The decrease in point source loading should have a major effect on Lake Apopka. However, internal nutrient loading from the lake sediments was not included in either the NES or Brezonik et al (1978) budget. The flocculent muck has high water, nutrient and organic matter content (see Section 2 - Bottom Conditions for more detail). Even though the muck presently serves as a net sink for nutrients, large amounts of nutrients are released whenever wind action mixes the lake water and resuspends the sediment. Nutrients also diffuse out of the sediment and affect water quality. A detailed examination of Lake Apopka sediment structure and processes currently underway at the University of Florida will increase the understanding of these two phenomena. A more accurate estimate of the effects of nutrient release on overall water quality will be possible when this research is completed. This internal source of nutrients must be included in any discussion of Lake Apopka's natural recovery.

Since some of the nutrient abatement programs are already in effect, an examination of the trends in water quality in recent years may be informative in evaluating the potential for Lake Apopka's natural recovery (see Section 2 - Existing Water Quality for more detail). In Lake Apopka, mean inorganic nitrogen and mean ammonia values have generally decreased from 1973-77, but have increased slightly since 1977. Mean phosphorus concentrations have also decreased since 1977. The other parameters (dissolved oxygen, organic nitrogen, and chlorophyll-a) either increased or remained approximately the same since 1973. While these trends do not indicate a significant improvement in Lake Apopka's water quality, neither do they indicate an overall decline in water quality since 1973.

In the downstream lakes, mean ammonia concentrations have decreased since 1973 and phosphorus values have decreased since 1977. The other parameters vary from lake to lake. Indications of improvement are more difficult to see in the downstream lakes since there is a lag between the water quality problems in Lake Apopka and their effects on these lakes.

The restoration of Lake Apopka under the no-action alternative is a long term proposal. Once pollution abatement has been completed, the potential exists for improvement of lake water quality. The decrease in external nutrient loading should be a major factor in limiting further deterioration; however, it should be noted that internal loading will remain a major source of nutrients. Wastes were first dumped into Lake Apopka in the 1920's. The lake's present condition is an accumulation of over fifty years of abuse. Therefore, even with the implementation of this extensive nutrient abatement program, recovery of a healthy lake ecosystem could take decades at best.

The no action alternative is inexpensive with no direct costs beyond the current waste abatement program. However, economic and aesthetic benefits normally associated with an unpolluted lake cannot be realized while Apopka remains in a degraded condition. Commercial and pleasure fishing revenues will remain insignificant due to the small populations of game fish, while recreational opportunities and aesthetic pleasures will continue at their current extremely low levels.

Another important concern when considering the no-action alternative is its effect on the lakes downstream from Lake Apopka. Since Lake

Apopka is at the head of the Oklawaha chain of lakes, the quality of its water has a direct effect on the quality of the water in the lakes downstream. The water quality data from 1973 to 1978 do not indicate any extreme deterioration of any of the lakes; in fact, many values improved from 1973 to 1978. With completion of the nutrient abatement program in mid-1980, water quality in the downstream lakes can be expected to improve or at least be maintained at current levels for most parameters. It should be noted, however, that downstream lake water quality is not only affected by pollutant loading from Lake Apopka but also by pollutant contributions from each of the individual lakes' watersheds. Any improvement in the water quality of the downstream lakes by the pollution abatement programs currently being implemented for Lake Apopka could be negated by any increase in pollutant loading in the individual lakes' watersheds. Therefore, land use practices which accelerate the movement of potential pollutants into these lakes should be discouraged in order to optimize benefits from the Lake Apopka pollution abatement program.

## Enhanced Fluctuation

The Oklawaha Chain of Lakes evolved under conditions of extreme water surface fluctuation. Natural fluctuations in lake levels resulted from variations in rainfall patterns, evapotranspiration, surface and groundwater inflow and outflow and geological conditions. As man developed the area, however, he altered this natural system of high and low water levels to satisfy his needs and to protect property. These water level stabilization efforts by the flood control districts and other agencies have been a major contributing factor to the increasing degradation of Florida lakes (Fox, Brezonik, and Keirn, 1977). Unregulated lakes have withstood abuse better than regulated lakes. The organisms inhabiting lake ecosystems in Florida have evolved under, and therefore are adapted to, periodic and sometimes extreme fluctuations of water levels.

The importance of fluctuating lake levels is multi-faceted. During the low flow period of the cycle, unconsolidated bottom sediments are exposed to air and sunlight, which allows the sediments to oxidize, dry out, and compact. If this cycle is repeated on a natural basis, unconsolidated flocculent sediments will not have a chance to accumulate and accelerate the eutrophication process. Also, consolidated bottom sediments release fewer nutrients and suspended solids to the water column, thereby retarding water quality degradation.

A consolidated lake bottom provides a suitable substrate for habitation of desirable aquatic macrophytes, for game fish spawning, and for a diverse assemblage of benthic invertebrates (Fox, Brezonik, and Keirn, 1977; FG&FWFC, 1974b). Such a diversified, stable lake ecosystem has a greater assimilative capacity for nutrients and pollutants than a lake with few aquatic macrophytes (ECFRPC, 1972b). The low pool stage of lake level fluctuation also allows light to penetrate to a greater area of the lake bottom due to the shallower water. Aquatic plants can then become established farther from the original shoreline, thereby increasing the lake's littoral zone. Studies by FG&FWFC personnel have shown that "...the lakeward limit of perennial emergent plants is related to historically low water elevations" (ECFRPC 1972b).

High stages of lake level fluctuations occur during the period of greatest rainfall. As the lake's volume of water increases, nutrients are diluted and the lake experiences a flushing effect. When the lake starts returning to a more normal or lower stage, many of these nutrients are removed from the lake. Therefore, the greater the fluctuation of a lake, the more flushing action will occur. This results in a shorter detention time for the lake and decreases the opportunities for nutrients to contribute to eutrophication.

When man reduced the fluctuation schedule of Lake Apopka and the entire Oklawaha Chain, he ignored the dynamic natural system under which the lakes had evolved. Stabilization of these water levels has since led to undesirable changes in the lakes' biological communities (SWFWMD, 1976). The most significant changes include accelerated accumulation of unconsolidated bottom sediments, nutrient enrichment due to a reduction in littoral zone vegetation, and a reduction in fish and wildlife populations. Thus, the lake level stabilization program implemented on Lake Apopka in the 1950's has contributed to the lake's degraded condition.

A review of Lake Apopka's history indicates a trend toward reduced fluctuation schedules. From 1942 to 1956, the lake varied in elevation a total of 1.6 m (5.3 ft), from 19.5 to 21.1 m (64.0 to 69.3 ft) msl (ECFRPC, 1972b). The surface elevation of Apopka is now maintained between 20.3 and 20.6 m (66.5 and 67.5 ft) msl (SWFWMD, 1976), and the lake would seem a likely candidate for enhanced fluctuation. The presently allowed 0.3 m (1.0 ft) of fluctuation is insufficient to produce any significant exposure of bottom sediments; no consolidation occurs and the associated benefits of fluctuation cannot accrue.

The degree of fluctuation in Lake Apopka could easily be increased since the sill depth of the tainter gates at the Apopka-Beauclair Canal Lock and Dam is 19.2 m (63.0 ft) msl. A periodic drawdown to 19.2 m, however, would expose only approximately 13% of Lake Apopka's bottom (RSB&W, 1978). Although such exposure could result in some consolidation of bottom sediments and expansion of the lake's littoral zone, these benefits would likely be insignificant and temporary. The exposed muck bottom must be at least 0.3 m (1.0 ft) above water level for significant consolidation to occur (Crapps, RSB&W, personal communication). However, even if the muck did consolidate and aquatic vegetation did expand when the lake level increased, this new growth would be covered by the turbid, phytoplankton-rich water. The resultant intense shading might adversely affect much of the newly established vegetation in the littoral zone.

Where the Apopka-Beauclair Canal joins Lake Apopka, the design altitude of the canal bottom is approximately 18.3 m (60.0 ft) msl (RSB&W, 1978). Thus, it would be theoretically possible to gravity drain the lake to 18.3 m, but this would require lowering the entire downstream chain of lakes far below their average levels. This in turn would entail modification and precise coordination of the various water control structures and require an intensive public awareness campaign. If the lake were drawn down to 18.3 m, 22% of the lake bottom would be exposed. Although the long term benefits of this drawdown are not quantifiable, substantial sediment consolidation and submerged macrophyte establishment would probably occur. However, even if these fluctuations were attempted in order to expose a segment of Lake Apopka's bottom, the time frame necessary for a successful schedule might be extensive. For example, Anderson (1970) estimated that it would take more than seven years to gravity drain Lake Apopka from 20.0 m (65.7 ft) to 18.9 m (62.0 ft) msl, without extensive downstream lake level modifications. Therefore, this is not considered to be a feasible fluctuation alternative.

If pumps were used to enhance the drawdown to 18.9 m, the fluctuation schedule would still require unreasonable periods of time due to the low head differential between Lakes Apopka and Beauclair (unless Lake Beauclair and other downstream lake levels were substantially lowered). In addition to the necessity of dredging the Apopka-Beauclair Canal and installing pump stations, the lake would have to be refilled before winter to provide frost/freeze protection for the citrus groves. Assuming all these conditions were met, and 22% of the lake bottom was exposed at 18.9 m msl, at least 9780 hectares (24,180 acres) of the lake would still be covered with a deep layer of unconsolidated sediments. When the lake was refilled, this material might be distributed over the recently dried bottom, thereby negating the benefits of consolidation. However, if Lake Apopka were allowed to undergo extreme fluctuation on an annual or semi-annual basis, then substantial benefits would most likely accrue.

Enhanced fluctuation has been increasingly recognized by State and local agencies as an important natural function of Florida lakes. To slow the eutrophication process of the Oklawaha Chain of Lakes, the Southwest Florida Water Management District (SWFWMD) and the St. Johns River Water Management District (SJRWMD) have worked on plans to enhance the fluctuation of these lakes. The SJRWMD is now in charge of regulating the lake stages and is evaluating the present operating levels. No schedule changes have been proposed as yet, but a mathematical model to simulate storm runoff in the Oklawaha Basin is being developed. When the model is completed, it will be used as a tool to evaluate current levels and recommend new regulatory stages (Winegardner, SJRWMD, personal communication).

Many problems have been encountered in proposing new lake levels for a greater fluctuation of the Oklawaha Chain of Lakes. Agricultural and urban development has occurred in the floodplains and shorelines of the basin since the lake stabilization program was implemented. Such cultural expansion makes it difficult to increase the fluctuation schedule significantly without impinging upon these developments (ECFRPC, 1972b). During low water elevations, the lakes are less accessible, and some canals become non-navigable due to the shallower water. Thus, recreational fishing and boating are adversely affected. When the lakes are at maximum operating levels, many landowners fear that dikes will fail and cause flooding of homes and important agricultural lands (Winegardner, personal communication). It is because of these constraints that the current fluctuation schedule is so moderate in design. The lake's water quality is not expected to improve under such a moderate fluctuation schedule. However, any increase in fluctuation would be beneficial (SWFWMD, 1976), even though improvement of the lake's degraded condition may not be expected for many years.

## Aeration

Aeration of a lake is the use of compressed air or pure oxygen or mechanical pumping of air to increase the dissolved oxygen content of the lake, especially of the bottom water (Fast, 1975). Many eutrophic lakes experience semi-annual periods of oxygen depletion with microbial decomposition of organic matter primarily responsible for this shortage of oxygen. However, Lake Apopka is shallow and well-mixed by wind action. Oxygen rich surface water constantly replaces oxygen-depleted water near the bottom. In spite of tremendous amounts of decomposing organic matter, no significant oxygen depletion has been documented in Lake Apopka. From this standpoint, aeration of the lake would not be expected to significantly improve water quality or lead to the recovery of any desirable species of plants or animals.

Bottom sediments may also be affected by aeration. Experimental work tentatively suggests that release of compressed air at the water-sediment interface of a lake may enhance the aerobic decomposition of the organic sediments. However, this process is poorly understood, with key questions remaining to be answered. Until these questions are investigated, the use of aeration to deal with problems associated with flocculent sediments will remain a speculative possibility.

Since preparation of the DEIS, DER received a proposal from Clean-Flo Laboratories, Inc., of Hopkins, Minnesota, to aerate and restore Lake Apopka. A brief description of the proposal is presented here; for more detail, see Appendix C. Two processes would be utilized in the aeration proposal. Multiple inversion or mixing would be used to oxygenate bottom water. Multiple inversion of Lake Apopka would require compressors, Clean-Flo microporous ceramic diffusers and almost 1,000,000 m (3,000,000 ft) of tubing. In theory, the diffusers would be placed on the bottom of Lake Apopka and would release bubbles which would rise to the surface bringing bottom water with them to be oxygenated. The other process would be to seed the bottom of Lake Apopka with "beneficial organic sediment consuming micro-organisms". Over 100,000 liters of these "sediment-consuming" bacteria would be added to Lake Apopka in order to, in theory, consume the flocculent muck and accelerate establishment of the food web. The estimated cost of the project at 1978 prices is $11,259,000 and the project would extend over ten (10) years.

The basic concepts in the Clean-Flo proposal are that aeration will turbulently mix Lake Apopka and oxygenate the water and that this oxygenation along with the "sediment-consuming" bacteria will alleviate some of the problems associated with the flocculent sediments. However, the overriding premise in the Clean-Flo proposal is that Lake Apopka requires aeration. Lake Apopka, due to its morphology, receives more than adequate oxygenation through turbulent mixing by wind action. Furthermore, the ability of the "mystery microbes" coupled with aeration to alleviate sediment related water quality problems is still speculative. Therefore, the Clean-Flo proposal was found not to be a cost effective means of restoring Lake Apopka.

## Dredging

The primary advantage of dredging as a lake restoration technique is that it removes nutrient-rich sediments from the lake bottom, thereby preventing nutrient recycling. Water quality is often improved due to and urban development has occurred in the floodplains and shorelines of the basin since the lake stabilization program was implemented. Such cultural expansion makes it difficult to increase the fluctuation schedule significantly without impinging upon these developments (ECFRPC, 1972b). During low water elevations, the lakes are less accessible, and some canals become non-navigable due to the shallower water. Thus, recreational fishing and boating are adversely affected. When the lakes are at maximum operating levels, many landowners fear that dikes will fail and cause flooding of homes and important agricultural lands (Winegardner, personal communication). It is because of these constraints that the current fluctuation schedule is so moderate in design. The lake's water quality is not expected to improve under such a moderate fluctuation schedule. However, any increase in fluctuation would be beneficial (SWFWMD, 1976), even though improvement of the lake's degraded condition may not be expected for many years.

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Bottom sediments may also be affected by aeration. Experimental work tentatively suggests that release of compressed air at the water-sediment interface of a lake may enhance the aerobic decomposition of the organic sediments. However, this process is poorly understood, with key questions remaining to be answered. Until these questions are this removal of a large nutrient source. Furthermore, dredging deepens the lake, increasing the usable area of the lake for recreational purposes. This deepening can also reduce wind and wave resuspension of the remaining muck sediments, since wave induced turbulence decreases as lake depth increases. Furthermore, if Lake Apopka were deeper, the increased lake volume would be to the citrus growers' advantage by providing potentially greater frost/freeze protection.

In northern lakes which are made deeper by dredging, the lake water can become stratified with regard to water temperature. During the summer when maximum phytoplankton growth occurs, nutrients from the remaining sediments can be trapped in the cold water layer at the bottom, thus limiting the amount of nutrients available for propagation of phytoplankton blooms. However, this nutrient-restricting stratification benefit does not occur in shallow, subtropical lakes, due to the relatively limited temperature range of the water and the mixing caused by wind action.

The disadvantages of dredging are numerous and in many instances overshadow the benefits derived from this restoration technique. While bottom sediments act as a source of nutrients, they also act as a nutrient sink. A balanced equilibrium exists in lakes between the nutrients in the sediments and the water column. Dredging may expose nutrient-poor sediments which have a lower nutrient absorptive capacity, thus weakening the ability of the lake to cope with new nutrient inputs (Sargent, 1976). However, Fox, Brezonik, and Keirn (1977) indicated that the muck of Lake Apopka is saturated with nutrients and that any agitation releases, rather than stores, phosphorus and nitrogen. Thus, while the newly exposed bottom would cause no new problem, the process of dredging could release nutrients from the sediment through the agitation of the bottom material, thus further degrading water quality in Lake Apopka and the entire chain of lakes.

The agitation caused by the dredging process can adversely affect a lake by making more nutrients available for phytoplankton growth. As the phytoplankton increase in number, light transmission through the water is decreased. This could adversely affect littoral vegetation. Furthermore, as the phytoplankton die, they sink to the lake bottom adding to the accumulation of flocculent organic matter. The dredging of lake bottoms also results in abnormally high turbidity levels in the water column, further reducing light transmission and exerting a smothering effect on aquatic plants and animals. This may be especially true for Lake Apopka, since dredging such extensive deposits of muck would require at least four to five years. A 1970 study at Seattle University showed that this "suspension of the sediments can increase the oxygen uptake rate by a factor of ten" (Dunst et al, 1974). This could cause oxygen depletion and result in fish kills during the period of dredging.

In the process of removing the bottom material, benthic invertebrates would also be removed. Although Apopka currently has a limited variety of bottom dwelling organisms, these animals serve as an important food source for game fish. Long-term studies at the University of Wisconsin indicate that more than two years are required for re-establishment of the bottom fauna after dredging (Dunst et al, 1974). In a similar manner, the dredging process would remove dormant seeds of aquatic vegetation which are important for expansion of the littoral zone in the restored lake. Thus, dredging would seriously delay the re-establishment of a healthy and productive lake ecosystem. This delay does not conform well with the project objective of providing aquatic habitats capable of supporting substantial game fish and wildlife populations.

It has been estimated that Lake Apopka contains 222,000,000 $m^3$ (290,000,000 $yd^3$) of flocculent organic material. To realize substantial long-lasting benefits from the dredging alternative, a major portion of this muck must be removed. Otherwise, the remaining material would be distributed over the "restored" lake bottom, negating the potential benefits in these areas. Various dredging methods are available to remove the bottom sediments, but environmental damage and operational costs are important considerations.

Using the dragline method to dredge Lake Apopka would cost approximately $127 million (FDPC, 1971; corrected to 1978 cost index from the

U.S. Department of Commerce, 1978); however, this method would cause extreme turbidity problems and environmental damage. The cost estimate also does not include disposal costs for the muck that would be removed. This is an important consideration in that the return waters from dredge spoils are high in nutrient concentrations and, if not treated properly, can cause further environmental damage (Dunst et al, 1974). Therefore, this method of dredging is not environmentally acceptable at any cost due to its potential for degrading Lake Apopka and the entire downstream chain of lakes.

To ensure that water quality is not degraded to any great extent, an airlift suction method of hydraulic dredging could be utilized at a cost of approximately \$3.90 - \$4.50/$m^3$ (\$3.00-\$3.50/$yd^3$). At this unit price it would cost \$870 - \$1,015 million to dredge all of Lake Apopka. Again, this estimate does not include costs for disposal, handling, transportation, and processing of the dredged spoils. Thus, the cost of implementing dredging as the restoration technique for Lake Apopka appears to be prohibitively expensive both economically and environmentally.

Suggestions have been made to offset the high cost of dredging by utilizing private capital to remove the muck and recycle it as a marketable product. In theory, this recommendation has merit because it would defray the cost of the restoration by using the private enterprise system. Instead of the muck being discarded as a nuisance, it would be processed and put to some beneficial use. However, certain problems exist with this proposal which prohibit it from being implemented in the near future.

The most logical use of the muck would seem to be spreading it on the adjacent farms to the north of the lake. This seems especially attractive since the poorly drained soils on which these farms are based lose a layer of organic material each year due to oxidation. Unfortunately, the muck dredged from the bottom of Lake Apopka is not equivalent to soil used on the farms. The muck would have to be processed (spread and dried while being continuously plowed so as not to consolidate) before it could be utilized. This process would be quite expensive and most farmers are not willing to invest enough capital to make the dredging and processing alternative financially feasible. Any attempt to place dredged muck directly onto existing farm fields would ruin the present irrigation systems.

Another proposal for utilizing Lake Apopka's bottom sediments considered processing the muck to produce methane gas, which could be sold as fuel. This commercial project is particularly desirable in light of the present energy situation and would solve the problem of where to discard the sediments. However, conversations with W. M. Cauthen, of Florida Gas Corporation, indicated two major problem areas with this proposal: (1) Additional technology is needed before this gasification process is commercially feasible. Thus, it would be a minimum of five years before dredging could begin. (2) In order to reduce overhead, a company would only build facilities large enough to process the available muck over a minimum 15-year period Thus, dredging operations would last at least 15 years, probably longer.

Several other companies have expressed an interest in utilizing the muck as a resource, but could not identify a market for a finished product which would make the operation financially feasible. A California based firm, Ventra-Vac, Inc., is considering dredging the muck and processing it into a usable soil conditioner. The company utilizes a method which combines removal of the muck with an in-line treatment system to filter out sand and silt, oxidize out heavy metals, and treat organic pollutants in a manner similar to sewage treatment. An air lift suction dredge would be used to remove the bottom sediments and company officials feel their process could meet the strict permitting standards that would apply to any attempt at dredging Lake Apopka (Huntley, Ventra-Vac, Inc., personal communication).

Financial consultants for the firm are presently analyzing samples of the muck to determine a product that would offset the high costs of dredging and processing, and still provide a margin for profit. If a suitable market is identified, Ventra-Vac will then develop a detailed plan for dredging using a combination of equipment. Potential recycling plans that have been considered include the following: (1) Process the muck for horticultural uses. However, preliminary analyses show the muck would not be fibrous enough to be competitive with current products. (2) Blend the processed muck with organic matter from garbage to produce a compost material. (3) Till the product into sandy ground on newly developed residential lots to improve soil fertility. To date, this use seems to have the best potential, but final market feasibility studies have not been completed.

Organic Recycling International, Inc., was also considering using the Ventra-Vac technique to dredge Lake Apopka's bottom. Plans then called for using an "annelidic conversion" method to process the muck into a marketable product by culturing it with earthworms (Klauck, President of ORI, Inc., personal communication). Worm castings produced by this conversion method would then be used to enrich and improve soil. (See Appendix C for more details). This "vermicomposting" process, however, could require up to 200 years to treat Apopka's muck and is not considered financially feasible. The original plan was submitted with the idea of partially offseting the cost of a government financed dredging operation.

Dredging is generally environmentally damaging to a lake ecosystem. However, if extensive precautions were taken to minimize agitation of the bottom sediments and provide adequate spoil disposal treatment sites, private capital could be utilized to dredge, process, and market Lake Apopka's muck. It should be stressed that these environmental precautions make this alternative extremely expensive. It is a commendable idea to process the muck as a misplaced resource by supplementing our energy supplies or producing a usable product; however, the technology is not yet available to convert the muck into a marketable product. Until such a product is identified which will generate enough revenue to offset the high cost of dredging, disposal, handling, transportation, and packaging, the dredging alternative cannot be considered an acceptable restoration technique for Lake Apopka.

## Other Alternatives

During the EIS process, several alternative proposals for restoring Lake Apopka were submitted to DER by interested individuals. The technical staff of DER reviewed each of these proposals in detail and communicated with the appropriate authors concerning specific problems and constraints associated with each plan. Although these restoration proposals were unsolicited and are sincere in their efforts to restore the lake, none of the alternatives adequately addresses the problem of bottom sediment stabilization. In addition, any restoration of a 124 square kilometer lake contains inherent design problems due to the sheer magnitude of the project. These proposals, although preliminary in design, could not adequately resolve many of these problems. For a variety of reasons, therefore, none of these proposals was considered an appropriate replacement for the proposed drawdown scheme. Appendix C includes copies of all submitted proposals and correspondence related to each.

# SECTION 4

# DESCRIPTION OF SELECTED ALTERNATIVE

## Selection

The Draft Environmental Impact Statement explained in detail why drawdown was chosen as the recommended alternative for restoring Lake Apopka. Of all the techniques examined, only dredging and drawdown were capable of restricting the release of nutrients from the highly flocculent bottom. Dredging has been reexamined in this document but is still found to be prohibitively expensive unless private capital can develop a market for the muck. In light of this conclusion, drawdown is still recommended as the most feasible restoration technique for Lake Apopka. This section discusses changes in the drawdown design as proposed by RSB&W, analyzes concerns raised over the project, and makes recommendations for a more feasible implementation of the restoration plan.

It must be emphasized that nutrient abatement and enhanced fluctuation remain important secondary restoration techniques to any proposed alternative. Nutrient abatement around Lake Apopka has progressed considerably and the completion of this program should be actively pursued. Enhanced fluctuation of lake levels is also important to the recovery of Lake Apopka because a return to a more natural system would prolong the beneficial effects realized through restoration. A wider range of lake level fluctuations simulates natural conditions and would provide beneficial maintenance of the littoral zone. The SJRWMD is encouraged to complete their analysis of the Oklawaha Chain and make new recommendations based on a more natural hydroperiod. At the very least, the frequency of Lake Apopka's fluctuation should be increased substantially.

## Revised Engineering Design

Since the distribution of the Draft EIS, final engineering design for the proposed drawdown of Lake Apopka has been conducted by RSB&W. The preliminary design, as described in Appendix B of the Draft EIS, was modified to reflect additional data gathered during the final design field work. The most significant design changes resulted from a more comprehensive understanding of the extremely poor soil conditions affecting nearly every aspect of the project. These major changes are discussed below, but the reader is encouraged to review the entire revised design contained in Appendix B of this document for a better understanding of the project.

The following list summarizes the most significant design revisions:

1. In-lake sedimentation basin. The shape of this basin was elongated to approximately 1160 x 305 m (3800 x 1000 ft). This longer, narrower design provides for a greater loading capacity and more efficient removal of suspended sediments.

2. Pumping stations. Because of the poor soil conditions underlying the pumping stations along the Apopka-Beauclair Canal, cofferdams had to be redesigned to provide an adequate foundation. Pumps are still positioned on top of the cofferdams, but the drive units have been moved to the side of the canal. Also, the cofferdams, which were originally double sheeting filled with suitable material, are now of a cellular design. This style is stronger and provides an extra measure of safety.

3. Dora Canal Bypass Pipeline. The 2.1 m (7 ft) diameter corrugated metal pipe design now calls for a 1.1 cm (7/16 in.) thick steel pipe with welded joints. Because of the high velocities and large volumes of water the pipe will carry through Tavares, this change was deemed necessary to provide maximum protection to the public. Welded joints will maintain the pipeline's integrity, and the ductility of steel pipe will mitigate settling effects caused by poor soils.

At the south end of the Dora Canal, poor soils and other problems associated with a subaqueous crossing have enhanced the feasibility of an aerial crossing. The pipeline will be routed over the canal with the same vertical clearance as the railroad bridge. The route of the pipeline has also been changed slightly to minimize any deleterious impact on the cypress swamp which abuts the railroad easement.

4. Dead River Cofferdam and Boat Lift. This cofferdam has been changed from a double row of sheeting filled with suitable granular material to a single row of steel sheet pile. Heavier weight sheet pile sections, driven to greater depths than originally estimated, will provide the required dam stability. The capacity of the Travel Crane boat lift has been increased from 10 tons to 20 tons, and an extra fork lift type boat lift will be used to more effectively handle the smaller boat traffic. A removable section in the cofferdam has also been included to permit passage of boats from Lake Harris to Lake Eustis during the refill phase.

5. Lake Beauclair restoration. The two cofferdams used during this stage of the project have been changed from double sheeting with fill to single row steel sheet pile.

6. Irrigation facilities. The Willow Dike plan for muck farm irrigation has been replaced by a plan to irrigate through improved interior canals. The previous plan was abandoned because reconstructing parts of the Willow Dike would: (1) threaten the integrity of the Farmers Dike, (2) damage existing vegetation along much of the north shore of Lake Apopka, and (3) be severely complicated by the poor soil conditions in the north shore area. Details of the revised design for muck farm irrigation are contained in Appendix B.

7. Project cost. The preliminary engineering report estimated the net cost of the drawdown at $13,925,310. Changes in project design, as discussed above, have increased that cost estimate substantially. Heavier sheet pile sections, revised cofferdam construction, modification of irrigation systems, and additional dike protection, as well as the engineering uncertainties outlined below, have resulted in a new net cost estimate for a 1981 drawdown of $19,826,400.

Although the plan as envisioned by RSB&W represents the most practical solution for restoring Lake Apopka to date, some problems still have not been resolved. These concerns have been raised by three major groups since distribution of the DEIS: (1) the engineers of

RSB&W, through revision of the preliminary drawdown design, (2) concerned individuals, and (3) government agencies. These questions and problems are discussed below and should be more accurately understood before a project of this magnitude is implemented.

## Engineering Concerns

Preliminary engineering design work by RSB&W was completed in August of 1978. The engineers concluded that all of the constraints imposed on the project (DEIS, p. 116) had been satisfactorily resolved and that the proposed drawdown was technically feasible. They also were convinced that the project would consolidate or improve over 70% of the lake bottom, that it could be implemented with minimal adverse environmental impacts, and that the project design would adequately protect the interests of all affected parties. This included the muck farmers, citrus growers, and downstream property owners.

As previously mentioned, however, final design work revealed a much more complex project than had originally been envisioned. The most significant deterrent to successful completion of final design was the fact that extremely unstable soils underlie nearly every construction site for the project. This finding necessitated revising the drawdown design, and the engineers were no longer as confident that the project design would protect the interests of all affected parties. Therefore, RSB&W has recommended that further studies be conducted to determine the most cost effective method of resolving these engineering concerns.

The three aspects of the drawdown design which require further analysis are discussed below. These concerns are potential liabilities which must be addressed to the satisfaction of any insurance company before it would approve a bid bond or performance bond for the contractor in charge of the project.

1. Dike protection. It is extremely important to protect the more than 52 km (32 mi) of dikes (especially the Farmers Dike and the

Apopka-Beauclair Canal dikes) which would be affected in some way during the course of the proposed project. The existing dikes were not designed or constructed under any accepted engineering practices. Foundation materials are weak soils, typically muck and calcareous clay. In the past, sections of the dikes have failed and have been repaired with any available materials, resulting in highly variable structures. When Lake Apopka is drawn down, these dikes will be exposed and will consolidate and crack to some extent. As the lake refills, the sheer forces exerted on the dikes by the water could result in dike failure in some locations. To prevent such failures, the dikes must be improved and strengthened. However, because of the dynamic state of these dikes and the generally poor structural properties of the soils used in their construction, RSB&W cannot recommend "typical" improvement measures that would ensure the integrity of all the dikes throughout the project.

To delineate specific areas of the dikes which must be improved, the engineers have strongly recommended further geotechnical work. Without this additional work, the proposed project cannot be considered complete and ready for implementation. The best approach would be to conduct extensive soil explorations of the dikes during the initial construction phase of the project. The areas identified as needing support could then be reinforced with steel sheeting or a soil stabilization fabric. If necessary, inferior sections of the dikes could even be removed and replaced with suitable granular fill. Further precautions would be taken throughout the course of the project to monitor the stability of the dikes and predict problems as early as possible to institute improvement or repairs (See Appendix B). Nevertheless, the initial geotechnical work and soil exploration work must be implemented prior to the project so that the dike failure liability concern can be resolved to the satisfaction of all parties.

2. Shoreline consolidation. The engineers have also expressed concern over the unknown effects of drawdown on upland soils surrounding Lake Apopka. Approximately eighty-five to ninety structures are located near enough to the lake to be potentially affected by the dewatering of soils resulting from the proposed drawdown. Depending on the soil type,

dewatering could cause significant consolidation and settling of shoreline structures, with possible damage to walls, floors, and foundations. Therefore, the engineers have recommended further geotechnical work and soil sampling near these structures to resolve some of the unanswered questions concerning shoreline consolidation.

This soil testing and analysis could be conducted during the initial stages of construction, similar to the dike protection geotechnical work. The results of these analyses would dictate where action must be taken to prevent settlement damage. Such action would include the use of fill, sheeting, and pilings to protect the structures. For those structures which do not require preventative work, the engineers recommend a monitoring system to determine any settlement of structures during the drawdown. Should any of these structures show signs of settling, immediate actions would be taken to minimize additional settling. Thus, uncertainties about shoreline consolidation do exist, but further geotechnical work can resolve many of these concerns.

3. Irrigation systems. Another important potential liability associated with the project involves supplying adequate amounts of irrigation water to the citrus groves and muck farms adjacent to Lake Apopka. If these irrigation systems were designed incorrectly or for some reason did not provide enough irrigation water at the correct time, the citrus and vegetable crops could be damaged. To prevent such an occurrance, RSB&W considered the demand for irrigation water at different times of the year and conservatively estimated the area of agricultural land affected by the proposed drawdown. However, the engineers now feel that without more detailed information relating to citrus and muck farm irrigation, the cost of supplying irrigation water could be very expensive.

The necessary information would be obtained through additional studies, including monitoring the water table in citrus and muck farm areas to better determine the relationship between drawdown and water table decline. Such studies would increase the accuracy of determining exactly which groves would be affected by the drawdown and to what degree. Also, these studies would delineate more precisely when the groves would need additional irrigation water and to what extent that additional need is caused by the pumped drawdown as opposed to natural factors. Thus, a better understanding of water table reaction to drawdown may reduce the risk and cost of irrigating agricultural lands during the project and is strongly recommended by RSB&W.

## Biological & Chemical Concerns

Since preparation of the DEIS, several important questions have been raised concerning the effects of the proposed drawdown on the biological, ecological and chemical integrity of Lake Apopka and the Oklawaha Chain of Lakes. Since these questions relate to the probability of success of the project and the degree of recovery of the lake ecosystem, they should be answered satisfactorily before any drawdown is implemented.

### Water Quality

One of the most important concerns expressed is that the water used to refill Lake Apopka would in essence be stored Lake Apopka water and might reduce or negate the beneficial effects of a drawdown. In addition, the waters of Lake Beauclair and Dora are of generally poorer quality than the water in Lake Apopka. Refilling Apopka with water stored in these lakes during the latter stages of drawdown and holddown will certainly cause unwanted nutrients, algae, and suspended solids to remain in Lake Apopka upon completion of the project.

Two major objectives of a Lake Apopka restoration are to improve water quality and to reestablish stands of aquatic macrophytes to enhance nutrient assimilation and support fish food organisms. The condition of the refill water directly affects both of these objectives. It is understood that the water quality of Lake Apopka may worsen to some extent during refill, due to organic decomposition and resuspension of sediments by scouring. The important factor, however, is the extent to which water quality will improve and aquatic macrophytes will expand after refill. The refill water will be high in nutrients and turbidity. This will result in poor water clarity (as measured by Secchi disc) and could discourage restoration processes. Since the refill will begin in August and the water will be turbid and high in nutrients, algae growth could be encouraged. It is possible, therefore, that these factors could cause phytoplankton growth to outcompete macrophytes and delay or even preclude the establishment of these macrophytes, which are important components of a healthy lake ecosystem. Thus, the blue-green algae, which were to be suppressed by a drawdown, could possibly propagate at the expense of desirable macrophytes.

Water used to refill Lake Apopka, however, will not be stored Apopka water per se. During drawdown, Apopka water will flush the downstream lakes, including Beauclair and Dora. Lakes Beauclair, Dora and Eustis will be held at the lowest recommended levels to facilitate drainage from Apopka and will be at their minimum levels when the downstream locks are closed at the end of drawdown. It is at this time that the storage of refill water begins. Water used to refill Lake Apopka, will come from the following sources:

1. Rainfall on Lake Apopka's exposed bottom and water surface;
2. Gourd Neck Springs; and
3. Water stored downstream: rainfall in downstream lakes; water pumped from Apopka during the latter stages of drawdown and holddown; and water stored in Lake Harris.

The hydrologist and engineers at RSB&W have estimated the contributions of the various sources of refill water under design dry conditions, average conditions, and design wet conditions (Table 4.1.). Using these figures and knowing the water quality of the various sources, the quality of refill water has been estimated (Table 4.2.). The proposed combination of sources should provide refill water of equal or better quality than that currently in Apopka. However, successful improvements in water quality will depend on several project conditions including rainfall, the extent of lake bottom consolidation, and the outcome of competition between phytoplankton and aquatic macrophytes. As Tables 4.1. and 4.2. illustrate, optimum conditions would occur under average rainfall conditions, assuming considerable muck consolidation and successful establishment

TABLE 4.1. SOURCES OF REFILL WATER AT 19.8 M MSL

| Source | Design Dry Conditions $\bar{x}$ - 1.96 sigma | Design Average Conditions $\bar{x}$ | Design Wet Conditions $\bar{x}$ + 1.96 sigma |
|---|---|---|---|
| Rainfall<br>Spring Flow<br>Runoff | 1% | 28% | 45% |
| Lake Eustis<br>Lake Dora<br>Lake Beauclair | 66% to 77% | 48% to 56% | 55% |
| Lake Harris<br>Little Lake Harris | 22% to 33% | 16% to 24% | 0% |

TABLE 4.2. ESTIMATED WATER QUALITY UNDER VARIOUS CONDITIONS[1,2]

|  | Apopka Annual mean 1977 | Refill water Dry year $\bar{x}$ - 1.96 sigma | Refill water Average year $\bar{x}$ | Refill water Wet year $\bar{x}$ + 1.96 sigma |
|---|---|---|---|---|
| Ortho-P mg/l | 0.047 | 0.025 | 0.028 | 0.065 |
| Total-P mg/l | 0.221 | 0.109 | 0.095 | 0.106 |
| Inorg-N mg/l | 0.095 | 0.116 | 0.191 | 0.249 |
| Chl-a mg/$m^3$ | 33 | 35 | 26 | 22 |

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[1] Source: Data for Lakes Apopka, Beauclair, Dora and Eustis and for rainfall taken from Brezonik et al, 1978; data for Lake Harris from STORET.

[2] For the purpose of these calculations it was assumed that:
(1) quality of water from Gourd Neck Springs equals that of rainfall;
(2) Chl-a levels of Lake Harris equal those of Lake Eustis;
(3) Under each of the three refill conditions, Lakes Beauclair, Dora, and Eustis contribute water in proportion to their volume (7100, 41,700 and 79,800 acre feet; or .06, .32 and .62, respectively).

of a littoral zone. The actual improvement in water quality is not quantifiable at this time and can only be calculated through scientific conjecture based on sources of refill and present water quality. Further testing is necessary to specifically document expected changes in water quality.

### Terrestrial Vegetation

During the drawdown of Lake Apopka, terrestrial weeds will invade the newly exposed lake bottom. This growth may lead to shading of the sediment, which could reduce or retard drying, although this effect may be counterbalanced by transpiration. These weeds will take up nutrients from the sediments and will stabilize the consolidating bottom. Thus, the weeds will be beneficial for the restoration of Lake Apopka. A potential problem exists, however, if the weeds remain in the lake upon refill. Many plants would be expected to die, releasing nutrients and decaying organic matter into the water, and depositing unconsolidated organic material over the recently dried lake bottom. Other plants may be uprooted, bringing sediment to the surface. Also, these floating mats of dead plants will be blown toward the shoreline and may inhibit growth of some new submergent vegetation due to shading.

As explained in the DEIS, terrestrial weed removal is very expensive under the conditions expected during the Lake Apopka restoration. It has been estimated that with current harvesting techniques it would cost in excess of $10,000,000 to remove the invading weeds (RSB&W, personal communication). In addition to its expense, harvesting the terrestrial vegetation could damage the crust of the newly consolidated lake bottom (for more detail, see page 142 - DEIS).

The productivity and nutrient content of the invading vegetation have been estimated in order to gain a better idea of the potential effect of these weeds. It is expected that the primary types of vegetation invading Lake Apopka's exposed bottom will be similar to the macrophytes which invaded Lake Carlton during its 1977-78 drawdown (viz., *Typha* (cattails), *Salix* (willow), and *Ludwigia* (primrose willow) (Florida Game and Fresh Water Fish Commission, 1978a). Freshwater emergent macrophytes (e.g., cattails) and semitropical vegetation (e.g., willows) have production rates from 2 to 14 g dry weight/$m^2$/d (Florida Game and Fresh Water Fish Commission, 1978a; Davis and Harris, 1978). Calculations of total biomass of the invading vegetation are based on the estimated productivity value of 8 g dry weight/$m^2$/d, and the area of exposed lake bottom available for macrophyte propagation at any given time during the drawdown. Results of these calculations indicate that approximately 100 million kg dry weight of vegetation will grow in Lake Apopka (see Table 4.3.).

TABLE 4.3 PRODUCTIVITY OF VEGETATION
EXPECTED TO INVADE LAKE APOPKA DURING DRAWDOWN

| | $m^2$ Exposed | g/$m^2$/d | d | g |
|---|---|---|---|---|
| April | 18.6 million | | | 4.46 billion |
| May | 74.4 million | | | 17.85 billion |
| June | 105.4 million | 8 | 30 | 25.30 billion |
| July | 105.4 million | | | 25.30 billion |
| August | 74.4 million | | | 17.85 billion |
| September | 24.8 million | | | 5.95 billion |
| October | 18.6 million | | | 4.46 billion |
| | | | | 101.17 billion |

*Typha* can grow in water up to 8 ft in depth, while *Salix* and *Ludwigia* usually inhabit areas where water depth is less than one foot. Only a small portion of the lake will be less than 1 foot deep upon completion of refill, resulting in the death of most of the invading *Salix* and *Ludwigia*. However, most of the *Typha* is expected to survive refill due to its tolerance of the maximum refill water levels. A 75 percent die-off represents a liberal estimate of the amount of invading vegetation expected to die during refill. This represents about 76 million kg dry weight of vegetation. The average phosphorus content of *Typha* and other emergent vegetation is approximately 0.07 percent dry weight (Wetzel, 1978). Therefore, the potential phosphorus content of affected vegetation represents 53,000 kg P.

Macrophyte decomposition follows logarithmic decay where initial nutrient release rates are more rapid than during later stages of decomposition. Therefore, after refill, approximately half of the invading terrestial vegetation phosphorus could be released into Lake Apopka by the end of one year. This is on the same order of magnitude as the phosphorus currently present in the readily available interstitial water of the sediments (28,000 kg P) (Brezonik et al, 1978). The nutrient release from invading macrophytes should be a temporary problem having significant effects only during the first year following refill. The long-term effects of terrestrial weed decomposition on water quality are not known. If the nutrients from the decaying weeds recycle after the lake is refilled, then the potential benefits of the drawdown restoration may be jeopardized. However, the expected weed problems, in themselves, are not expected to out-weigh the anticipated benefits of the proposed lake drawdown. In conclusion, although the quantity of terrestrial weed biomass can be estimated, the effect of this decaying material in combination with the other drawdown impacts is not known. More specific studies or analyses of actual drawdowns are necessary to provide a more complete understanding of the total effects of this decomposition.

### Sediment Consolidation and Nutrient Release

Concern has been voiced that consolidation of Lake Apopka sediments would not inhibit the release of nutrients into the water column following refill. The potential for nutrient release from Lake Apopka sediment is of critical interest in evaluating the likelihood of water quality improvements resulting from the control of external nutrient sources and from a lake drawdown. The most comprehensive nutrient budget for Lake Apopka documents that the lake's sediments are presently a net sink for nutrients (Brezonik et al, 1978). However, once the abatement of external nutrient sources is finalized, the total influx of nutrients to Lake Apopka will be substantially reduced and nutrient sedimentation will be slower. Although the net flux of nutrients is into the sediments, a tremendous amount of phosphorus (28,000 kg P) can readily be recycled into the water column and represents a major source of phosphorus for phytoplankton propagation (Brezonik et al, 1978).

The mechanisms controlling sediment-water column nutrient cycling in shallow aquatic environments are primarily advective and diffusive processes. Currently, wind induced advective mixing of the flocculent sediments is the primary process responsible for sediment-nutrient recycling in Lake Apopka (see Section 2). Consolidation of sediments, resulting from lake drawdown, is expected to alter recycling of nutrients from the sediments. The advective wind mixing process will be replaced by the slower diffusive mechanisms, which should substantially reduce sediment-water column nutrient recycling.

Pollman and Brezonik (1979) have examined fluxes of nutrients from consolidated and unconsolidated Lake Apopka sediments. Since the diffusional flux varies with porosity (Manheim, 1970), it follows that the compaction and consolidation of Lake Apopka sediments resulting from drawdown will produce a subsequent decline in diffusion. A 30% decline in the diffusion of phosphorus was calculated for post-drawdown conditions of consolidation of surficial sediments (Pollman and Brezonik, 1979). In summary, the drawdown and accompanying sediment drying and consolidation are expected to reduce both the diffusional and advectional nutrient fluxes.

The proposed drawdown will expose approximately 85% of the lake bottom. However, since the water must be drained to 0.3 m below the muck for significant consolidation to occur, some 30% of the bottom will remain unconsolidated. In addition, some muck will undoubtedly erode from the gentle slopes of the lake bottom to the deep unconsolidated holes during drawdown and holddown. Upon refill of the lake, the unconsolidated muck will be in deeper regions of the lake. While the water depth of these deep areas does not preclude the possibility of muck resuspension and interstitial nutrient releases, the frequency of wind induced sediment resuspension will be less following consolidation. However, muck redistribution from the deeper regions of the lake is a major concern because it could eventually blanket extensive areas of the

TABLE 4.4. LAKE APOPKA WATER QUALITY FOR DRAWDOWN STAGE ELEVATIONS[1]

| Lake Stage Ft (MSL) | Suspended Solids (MG/L) | Turbidity (NTU) | No. of Days of Flow | Projected Influent Water Quality |
|---|---|---|---|---|
| 66 | 50-100 | 10-12 | 26 | Surface Water |
| 65 | 75-125 | 10-30 | 24 | Surface and Mid-Depth Water |
| 64 | 100-150 | 15-100 | 22 | Mid-Depth Water |
| 63 | 1300-4000 | 260-700 | 20 | Mid-Depth and/or Floc Water 15:1 to 3:1 Water to Muck Ratio |
| 62 | 3000-6000 | 600-2200+ | 20 | Floc Water 7:1 to 1:1 water to Muck Ratio |
| 61 | 6000+ | 1500-2200+ | 12 | Floc Water/Muck Layer 5:1 to 1:1 Water to Muck Ratio |
| 60 | 6000+ | 2200+ | 4 | Muck Layer<br>1:1 Water to Muck Ratio |
| 59 | 6000+ | 2200+ | 3 | Muck Layer<br>1:1 Water to Muck Ratio |
| 58 | 6000+ | 2200+ | 2 | Muck Layer<br>1:1 Water to Muck Ratio |

[1] Source: RSB&W, 1978

consolidated bottom. Potential nutrient release from this redistributed muck could be large, quite possibly on the same order as that released from pre-drawdown muck. The establishment of a macrophyte (Typha) community around the deep holes may mitigate the effects of wind action on the redistribution of the deephole muck. However, if muck redistribution does occur, the probability of long-term success of the drawdown will be substantially reduced.

Concern has also been expressed over the possibility of degrading the water quality of the lakes downstream of Apopka. As Lake Apopka is drawn down, the decrease in water depth will allow the sediment to be more easily resuspended. This will tend to release nutrients and sediments to be transported downstream (Table 4.4.). However, one of the design constraints of the project was to minimize both nutrient and sediment transport. An in-lake sedimentation basin will be used to alleviate downstream effects during drawdown. This basin has been designed to handle 3:1 surface water to muck ratio such that nutrients and sediments would be efficiently removed (Table 4.5.). After sedimentation, water released downstream would have nutrient concentrations similar to those currently being reported downstream. An adjustable weir will minimize sediment carry over. However, any sediment that is pumped out of Lake Apopka will settle out in Lake Beauclair. The subsequent drawdown of Lake Beauclair which is included as part of the proposed project, will consolidate these sediments. Although such an event is not expected to occur, should effluent from Lake Beauclair become unacceptable, pumping will cease until acceptable levels are attained. In addition, there could be a pulse sediment discharge downstream during a period of severely inclement weather. In such a case there may be an initial increase in nutrient and sediment levels followed by a return to pre-discharge condition. Nevertheless, the impact of this low level suspended sediment should be minimal.

During the drawdown of Lake Apopka, there will be an increased transport of Lake Apopka water downstream. The impact of this increased transport on downstream lakes is difficult to evaluate since all of the lakes are considered eutrophic, and since Lake Beauclair and Lake Dora have poorer water quality than Lake Apopka (Brezonik et al, 1978). In any event, since the effects of Lake Apopka discharges are currently felt in all of the downstream lakes, the water quality of downstream lakes is not likely to improve until Lake Apopka improves.

TABLE 4.5. ESTIMATED REMOVAL EFFICIENCY[1]

| Parameter | Influent | Effluent | Percent Removal |
|---|---|---|---|
| Turbidity (NTU) | | | |
| 3:1 water to muck ratio | 260-700 | 25-55 | 90-92 |
| 3:1 water to muck ratio | 600-2200 | 25-73 | 96-97 |
| Suspended Solids (mg/1) | | | |
| 3:1 water to muck ratio | 1300-4000 | 20-60 | 98 |
| TKN (mg/1) | | | |
| 3:1 water to muck ratio | 329 | 17.5 | 95 |
| 3:1 water to muck ratio with 985N @ 2 mg/1 | 372 | 14.2 | 96 |
| Total Phosphorus (mg/1) | | | |
| 3:1 water to muck ratio | 12.8 | 0.80 | 94 |
| 3:1 water to muck ratio with 985N @ 2 mg/1 | 12.7 | 0.53 | 96 |

[1] Source: RSB&W, 1978

## Littoral Zone Expansion and Game Fish Propagation

The reestablishment of rooted aquatic macrophytes would be of great benefit to Lake Apopka. These plants would compete with phytoplankton for nutrients and provide forage and cover for gamefish. Concern has been expressed that the water in Lake Apopka after the proposed drawdown would not be sufficiently clear for reestablishment of the rooted aquatic macrophytes. However, submerged macrophyte establishment has occurred in past Florida drawdowns. Macrophytes became established in Lake Carlton even though it was refilled with turbid, nutrient-rich Lake Beauclair water (Florida Game and Fresh Water Fish Commission, 1978a). The area of rooted macrophytes in Lake Tohopekaliga increased 16% after drawdown and refill. However, Lake Tohopekaliga, prior to its drawdown, had a littoral zone of approximately 3642 hectares (9000 acres) (Holcomb and Wegener, 1974). The extent of littoral zone presently established in Lake Apopka is insignificant (9.9 hectares). Therefore, the extent to which Lake Apopka's much smaller littoral zone will expand is another of the unquantified biological effects of the proposed project.

The drawdown of Lake Apopka will compact and consolidate a large percentage of the lake's bottom sediments. Thus, less flocculent material will be available for resuspension. In addition, refill water for Lake Apopka is expected to be of equal or better quality than the present Lake Apopka water. This, along with the reduction in nutrients from consolidation, should lead to improved clarity. Therefore, the firmer bottom presented by the consolidated sediment should aid in re-establishment of rooted aquatic macrophytes. Aspects of the drawdown which could adversely affect the growth of these plants are the possible redistribution of the remaining unconsolidated muck and the decaying terrestrial vegetation which will provide nutrients for phytoplankton and some floating mats of vegetation. This undesirable plant life may shade new rooted aquatic macrophyte growth. Thus, although the area of aquatic macrophytes is expected to expand, the extent of such expansion on Lake Apopka is not known.

The drawdown of Lake Apopka and subsequent improvement of water quality and rooted macrophyte productivity should bring about an increase in the lake's game fish population. The rooted macrophytes will provide more forage and cover and the consolidated sediments will provide spawning grounds for game fish and substrate for a greater population of fish food organisms. All other Florida lakes subjected to drawdowns have shown dramatic increases in game fish populations. A resurgence and strong reproduction of gamefish occurred in Lake Griffin following its drawdown in 1973. Gamefish in Lake Trafford increased from 20% to 76% of the total catch five years after a partial drawdown. The annual large-mouth bass catch in Lake Tohopekaliga increased from 16,159 in 1970, before an artificial drawdown, to 61,523 in 1975 (FG&FWFC, 1978b).

The extent of gamefish increases in Lake Apopka will depend on the improvement in water quality, but populations should certainly stabilize at levels higher than those currently existing in Lake Apopka.

In summary, legitimate concerns have been expressed over the biological impacts of the proposed Lake Apopka drawdown restoration. Although other Florida lakes have experienced successful drawdowns and beneficial results, none of these lakes was as degraded as Lake Apopka. Thus, this project is unique. The quantity of water to be pumped, the extent of unconsolidated muck, and the restrictive time schedule make predictions for all these impacts quite difficult. Due to a lack of pertinent data and the high cost of implementing the proposed drawdown, the above mentioned concerns warrant a reassessment of the recommended restoration alternative.

## Revised Recommendation

Drawdown is still the most feasible method of addressing the internal nutrient recycling problem in Lake Apopka. The internal nutrient loading from the sediments will be greatly reduced through compaction and consolidation of the muck. The resulting increased water clarity would allow development of a vegetated littoral zone and improved game fisheries. Drawdown is much less expensive than dredging and has been shown to be at least partially successful in many Florida lakes. Lake Tohopekaliga, Lake Jackson, Merritt's Mill Pond, Lake Trafford, Lake Eola and Lake Griffin saw improved game fish populations after drawdowns. Furthermore, water clarity and littoral vegetation increased in Lake Tohopekaliga, Lake Trafford, Lake Hancock and Lake Griffin.

Although drawdown has been shown to be a valuable tool in lake restoration efforts, the previously mentioned technical problems still exist in the proposed Lake Apopka drawdown restoration. Potential engineering problems such as dike failure, shoreline consolidation, and irrigation system design, as well as biological-chemical problems associated with refill water, terrestrial weeds, nutrient release from consolidated sediments, redistribution of unconsolidated muck, nutrient-sediment release downstream, reestablishment of aquatic macrophytes and long-term changes in fish populations have not been adequately addressed. Discussion concerning these problems is still largely conjectural. There would be benefits gained from the proposed drawdown, but the extent and longevity of the benefits can only be estimated based on numerous assumptions.

Since the probability and degree of success of the $19.8 million Lake Apopka drawdown are unknown, the project cannot be considered cost effective. Benefits from the proposed drawdown have been estimated based on previous drawdown results. However, the biological and chemical impacts of the project are still not totally understood, and it is virtually impossible to state when returns from the drawdown would surpass total expenditures. Therefore, the recommendation is made to phase the restoration program using short-and long-term plans. The short-term plan includes continued monitoring of water quality in Lake Apopka and downstream lakes, and implementation of a test drawdown of a smaller lake having similar characteristics to Lake Apopka. The long-term plan includes continued exploration of restoration alternatives and methods which address the internal nutrient loading problem. The drawdown alternative will also be pursued further, contingent upon the results of the recommended studies.

### Short-Term Plan: Monitoring

Monitoring of the water quality in Lake Apopka and in downstream lakes should continue even though no direct action is being taken to restore Lake Apopka at the present time. The water quality in the downstream lakes is apparently not degrading at this time (see Section 2), but monitoring would provide specific documentation of any water quality trends. The waste abatement programs for Lake Apopka are scheduled for completion in 1980. The effects of these programs and predictions for natural recovery of the lake should be examined before an expensive restoration project is implemented. Thus, monitoring would document the present condition of the lake, while technical problems associated with drawdown are examined in greater depth.

The parameters to be monitored would be essentially the same as those monitored by Brezonik et al (1978) and Tuschall et al (1979). Monitoring of the following parameters is required by EPA when using federal funds for lake restoration: nitrate-nitrogen; nitrite-nitrogen; ammonia-nitrogen; Kjeldahl-nitrogen; organic nitrogen; ortho-phosphate; total phosphate; temperature; Secchi disc (water transparency); dissolved oxygen; chlorophyll-a; pH; and alkalinity. The following important water quality parameters should be measured also: turbidity; specific conductivity; dissolved silica; total organic carbon, dissolved organic carbon, and dissolved inorganic carbon; benthic invertebrates; zooplankton; phytoplankton; phaeophytin; and primary productivity. The cost for twelve months of sampling, based on a current DER contract with the University of Florida for monitoring Lake Apopka, is approximately $50,000.

## Short-Term Plan: Test Drawdown

In addition to monitoring Lake Apopka and downstream lakes, it is proposed that a test drawdown be implemented on a smaller lake with characteristics similar to Lake Apopka. This small scale drawdown would permit observation of the specific biological impacts of drawdown and would provide opportunities for intensive studying of problems facing the Lake Apopka drawdown, but at a much lower cost. A more accurate estimate of the probability of success of the proposed drawdown could be made with the information gained from such a test drawdown. This would permit a more reliable decision to be reached concerning actual implementation of the proposed project.

Names of potential test drawdown lakes were solicited from the Directors of the Pollution Control Boards in Lake and Orange Counties. Five of these lakes were examined by DER limnologists. Lake Mare Prairie in Orange County was found to most resemble Lake Apopka biologically, physically (muck conditions), and in water quality characteristics. Lake Mare Prairie is a 52 hectare (129 acre) lake in southeast Orange County, just north of the Orlando International Jetport. The lake has a surface elevation of 26 m (84 ft) msl, and an average Secchi disc reading of 0.3 m (1.0 ft), with an outflow to Boggy Creek. As a result of receiving storm drainage from approximately 21 $km^2$ (8 $mi^2$) of pasture land, the lake has become hypereutrophic. The primary source of enrichment has been a dairyfarm (pasture, feedlot and milking parlor) which discharged directly into a canal discharging into the lake. Waste abatement procedures have been implemented for Lake Mare Prairie. Legal enforcement to halt and correct runoff from the sizable dairy acreage, located to the north of the lake, was initiated in March 1973. Corrective measures to retain all runoff were initiated in October 1973 and completed in June 1974.

Like Lake Apopka, Lake Mare Prairie currently experiences a continuous algal bloom. Chlorophyll measurements are usually 100 $mg/m^3$ with algal counts in excess of 50,000 algae/ ml. Numerous fish kills have been documented since 1970. Until recently, the primary cause of these fish kills was assumed to be oxygen depletion resulting from the continuous algal blooms. However, early 1977 investigations have shown that fish pathogens (Aeromonas, sp.) are, in part, a contributing factor (Orange County Pollution Control Department, personal communication). More detailed water quality data (1967-1977) are available from the Orange County Pollution Control Department.

The following construction activities would be required to facilitate a test drawdown of Lake Mare Prairie:

1. Bypassing the water control structure located on the Boggy Creek outflow to allow for a gravity drawdown to a significantly lower surface elevation;
2. Dredging of channels connecting the two basins of the lake to the outflow area; and
3. Installing facilities for a pump to be used during the latter stages of drawdown.

Several unanswered problems associated with lake drawdowns can be examined during this test drawdown. It is proposed that the following aspects be specifically addressed:

1. Degree and longevity of sediment consolidation;
2. Muck redistribution from unconsolidated areas of the lake bottom after refill;
3. Invasion of terrestrial vegetation on exposed lake bottom, including: succession, quantity, survival rate after refill, nutrient release from decomposition, and muck formation by decomposing vegetation;
4. Establishment of aquatic macrophytes after a successful restoration, including: succession, quantity, possible aquatic weed problems (hydrilla, hyacinths), effect on water quality, and effect on phytoplankton population;
5. Changes in fish populations, including: succession, quantity, breeding, and economic benefits (long-term); and
6. Effect of refill water on water quality, including: phytoplankton levels, nutrient levels, and clarity.

The cost of a test drawdown of Lake Mare Prairie, including the proposed drawdown studies, is substantially less than the full scale Lake Apopka drawdown. A rough estimate of the construction costs comes to $20,000: $5,000 to bypass the water control structure; $10,000 for dredging; and $5,000 for pump facilities. The related studies should cost approximately $50,000, bringing the total cost of a test drawdown of Lake Mare Prairie to $70,000.

This short-term plan for water quality monitoring and a test drawdown should answer many of the questions concerning the long-term success of the Lake Apopka drawdown. This plan also appears to be the most cost-effective lake management program at this time. Once this plan has been implemented, an assessment of the future restoration potential of Lake Apopka will become more feasible.

## Long-Term Plan: Positive Test Results

The long-term phase of the recommended alternative will involve the actual implementation of a restoration project for Lake Apopka. At present, the lack of data concerning the effects of a nine month drawdown/holddown/refill schedule makes it difficult to access the beneficial and adverse results of the project. Estimates and predictions have been made, but these conjectures may not be reliable enough to justify a $19.8 million project. Therefore, the eventual restoration technique for Lake Apopka will depend upon the findings of the test drawdown and related studies recommended for the short-term restoration phase.

When these additional studies are completed, there should be a much larger data base for the specific biological and physical effects of drawdown on a lake with Apopka's muck and water quality characteristics. The test results will indicate either that drawdown is a feasible restoration technique for Lake Apopka, or that it is not practical. Additional restoration plans will be formulated around this conclusion.

If recommended studies indicate that drawdown has a high probability of initiating recovery of the lake and the resulting benefits are expected to be significant and long-lasting, it is recommended that the proposed drawdown be implemented. However, this decision should consider not only expected revenues from recreationists, fish camps and related businesses, but the aesthetic importance and intrinsic values of a restored lake as well. The significance of such a precedent setting action to the future management of other natural resources is also an important consideration. Thus, even if the dollar benefits generated by the restored lake were not to equal total project costs, the restoration might still be considered cost-effective.

Assuming the drawdown project is approved, several courses of action become possible. First, the extreme drawdown as proposed by RSB&W could be implemented. The predicted effects of this project were addressed in the DEIS; however, certain adverse impacts of this design, such as possible dike failure, are significant and could affect many local residents. The decision to implement this plan, therefore, assumes that the engineers are assured that all such potential adverse impacts are properly addressed and contingency plans have been designed. Accordingly, it is recommended that if the drawdown is pursued, all the geotechnical work and soil sampling recommended by RSB&W (see Section 3) be completed. The Lake Mare Prairie test drawdown could be utilized to document some of these physical impacts, such as shoreline consolidation and the effects of drawdown on the water table. This work is considered essential to the project and would be coordinated with the biological analyses conducted during the test drawdown.

A second alternative for implementing an extreme drawdown involves revising the RSB&W engineering design to improve the probability of success while reducing the adverse effects of such a project. This revision could consist of minor changes to the current engineering plan or could entail a significant departure from the original drawdown idea. Unfortunately, as noted throughout the EIS process, each change in design to minimize adverse effects raises the cost of the drawdown.

The most expensive mitigative step involves the very restrictive time frame for the project to ensure that frost/freeze protection is provided for the citrus growers adjacent to the lake. This constraint would apply to any extreme drawdown of the lake; RSB&W devised the original restoration schedule to permit a lake level of 19.5 m (64.0 ft) msl during the winter season. Because of the economic value of these groves (approximately $32 million), it is not possible to conduct a drawdown without meeting this restriction. Any major revisions to the proposed drawdown design must meet this and all other constraints pertaining to a drawdown (page 116, DEIS). An example of a proposal to draw down the lake in successive sections is contained in Appendix C. Although this specific proposal is preliminary in nature and does not adhere to all the project constraints, it represents the type of alterations to drawdown that should be examined to possibly reduce adverse impacts. Any changes in design would be analyzed for their effect on the overall success of the restoration.

## Long-Term Plan: Negative Test Results

If the test drawdown and related studies indicate that a drawdown is not feasible for Lake Apopka, either because the lake would not be restored or because the benefits would be short-lived, the proposed drawdown would not be recommended. Other restoration techniques would then be reconsidered for implementation on Apopka.

Three alternative lake restoration methods that should be pursued regardless of the results of the test drawdown are: enhanced fluctuation, nutrient abatement and dredging. The importance of each of these alternatives is explained in Section 3. An enhanced fluctuation schedule for the entire Oklawaha Chain of Lakes would improve water quality. Continuation and enforcement of the nutrient abatement program will reduce the pollutant stress on the lake and improve the chances for a successful lake recovery. These two alternatives are not capable of restoring the lake by themselves, but would complement any direct restoration efforts.

Dredging could be a direct restorative undertaking or a complementary, secondary action. It theoretically could be the most cost-effective method of restoring Lake Apopka because marketing the muck as a product would permit a direct return on the money invested to dredge the lake. However, significant environmental problems must be overcome before dredging is considered more feasible than drawdown. Water quality standards cannot be violated and storage of the muck for later processing will require some innovative spoils disposal planning. Most importantly, a market for the muck must be located to make the entire operation financially feasible. To date, no such market has been identified. Obviously, without a use for the muck, dredging would not be recommended as a feasible restoration alternative.

The dredging alternative should be analyzed further even if the results indicate that drawdown is still the most feasible alternative for restoring Lake Apopka. If a market for the muck is identified before the drawdown design is finalized, the most cost-effective method can be used. If a market is found after the drawdown is implemented, the deep holes in the lake could be dredged. This action would still produce a significant amount of muck for processing and would also reduce distribution of the remaining unconsolidated muck over the improved lake bottom.

If neither drawdown nor dredging can be refined to the extent that they become feasible for Lake Apopka, a "no action" alternative is recommended. Naturally, enhanced fluctuation and nutrient abatement should still be pursued, but no major, direct action to restore the lake would be advisable. In such a situation, the only hope for restoration lies in some future breakthrough in technology that would improve the probability of success for a new restoration technique or for one of the alternatives described in Section 3 and Appendix C. In the interim period the lake would be a grim monument to man's abuse of a natural lake ecosystem.

In summary, a dual-phase restoration scheme is recommended for restoring Lake Apopka. The first phase entails further biological and engineering studies in conjunction with a test drawdown of a lake similar to Apopka. Preliminary surveys indicate that Lake Mare Prairie in Orange County is a likely candidate. The second phase would involve implementation of a restoration project based on the results of the test drawdown. If the studies are favorable, a drawdown should be implemented. If the tests are not supportive of a large scale drawdown, the possibility of dredging the lake and marketing the muck should be pursued and perfected. If this alternative cannot be perfected, the "no-action" alternative is the only remaining practical recommendation since no other restoration technique is currently feasible. Enhanced fluctuation and nutrient abatement are important secondary lake improvement techniques and should be implemented regardless of the final chosen restorative action.

## SECTION 5

## IMPACTS OF PROPOSED REVISED ALTERNATIVE

The effects of the proposed long-term restoration plan, which is the actual implementation of the Lake Apopka drawdown, have been analyzed to the fullest extent possible in the DEIS. Assuming the drawdown is implemented in the near future, these impacts would be essentially unchanged. However, if the drawdown is delayed for a long period or if the dredging alternative becomes feasible to the point of implementation, the impact analysis would require revision. The following impacts pertain to the short-term restoration plan.

### Water Quality and Biological Impacts

The short-term plan, which includes monitoring, a test drawdown, and related studies, would have the same impacts on the water quality and biology of Lake Apopka and the downstream lakes as the no-action alternative described in Section 3. However, the proposed test drawdown would, in addition, have an impact on water quality in Lake Mare Prairie. Since the test drawdown of Lake Mare Prairie is designed to answer some of the basic questions concerning the biological and water quality impacts of the proposed Lake Apopka drawdown, many of the impacts of the drawdown on Lake Mare Prairie are not known. Until the test drawdown is implemented, no concrete predictions can be made about the impacts on Lake Mare Prairie of terrestrial weed invasion, nutrient release from consolidated muck, redistribution of unconsolidated muck, re-establishment of aquatic macrophytes, and long-term changes in fish populations. However, the anticipated benefits of the Lake Mare Prairie drawdown are a consolidated bottom, reduced internal nutrient loadings, reduced incidence of phytoplankton blooms, improved water transparency, and re-establishment of aquatic macrophytes.

Lake Mare Prairie is connected to East Lake Tohopekaliga by Boggy Creek. However, the drawdown and anticipated restoration of Lake Mare Prairie will have no significant impact on East Lake Tohopekaliga or Boggy Creek. Currently, Boggy Creek receives runoff from dairy pastures and effluent from the City of Orlando Jetport STP. Water quality in this creek is rather poor with high nutrient values and fecal coliform counts. Any increased turbidity or nutrient loading to this creek due to the Lake Mare Prairie drawdown will be overshadowed by these pollution sources. Furthermore, because of the existing pollutant loadings, the anticipated benefits of the restoration of Lake Mare Prairie will not be felt downstream.

## Socio-Economic Impacts

The short-term restoration plan is relatively inexpensive to implement, with no direct costs beyond the current waste abatement program and the proposed test drawdown and associated studies. However, while the financial outlays of this phase are not significant, neither are the direct economic returns. In fact, until a restoration plan with a high probability of success can be implemented, the lake will not produce benefits any faster than at its current rate. The local economy has adjusted to Lake Apopka's present low-key role, but the additional revenues potentially associated with the lake cannot be realized while a no-action approach is taken. Thus, by delaying the proposed restoration until the plan is improved and refined, the lake will continue to contribute only minimal revenues. Recreational opportunities, commercial and pleasure fishing, revenues, aesthetic enjoyment, and numerous other related amenities of a healthy lake cannot be increased above their present low levels. In addition, the steadily climbing inflation rate and increases in construction and material costs will result in a higher project price tag when the restoration effort is implemented.

Lake Apopka's past and present condition is a perfect example of how the economic benefits of an area are directly related to the condition of that area's natural biological systems. A healthy ecosystem offers potential for a stronger, more diversified local economic basic. Lake Apopka was used, intentionally or not, to foster cultural beneficial returns on such a scale that only short-term results were considered, not long-term effects. Over a period of 50 years the lake produced continually diminishing returns until it reached its present degraded state of minimal benefits. To prevent this situation from occurring, changes to one component of a system must be analyzed as to their effects on all other parts of that system. Applying this analysis to the Lake Apopka experience in retrospect illustrates the importance of preserving valuable ecosystems rather than trying to recreate what has been spoiled.

The proposed test drawdown on Lake Mare Prairie will result in some beneficial impacts to that lake, which must be considered as part of the short-term restoration plan. Boating and fishing on the lake will be precluded during the drawdown period, but should increase following refill as water quality improves and fish populations expand. In addition, the Orange County Pollution Control Department has proposed the development of a 65 hectare (160 acre) park adjacent to the lake. Complete utilization of such a facility would not be realized until the lake is restored. One of the main transportation arteries leading to the Disneyworld and Seaworld complexes is located adjacent to Lake Mare Prairie and is heavily traveled by tourists. Since a majority of these travelers use automobiles or recreation vehicles, Orange County anticipates substantial utilization of the lake, particularly if the park area is developed. Therefore, a restoration of Lake Mare Prairie and subsequent development of the park would have a beneficial economic impact on the local community.

## Historical and Archeological Resources Impacts

The short-term restoration plan, which at a minimum entails a delay in implementing the proposed drawdown, should have no adverse effects on Lake Apopka's archeological resources. A preliminary time/cost estimate for an archeological survey of Lake Apopka has been conducted by the Florida Department of State, Division of Archives. The proposed survey would include a visual inspection of each site which would be physically affected or altered by the drawdown restoration plan. Archive officials estimate that the entire survey could be completed in four to seven weeks at a cost of $1600 to $2900, including field work and report writing. The four week estimate refers to ideal conditions during the survey. The seven week estimate includes time for poor weather conditions, access problems, and recovering any finds.

In addition to the areas affected by the pumping facilities, Archive officials indicate that the exposed lake bottom could reveal important artifacts such as dug-out canoes. Several specific areas have been identified as potential archeological sites, but these locales will not become public information for fear they would be vandalized. A formal survey plan will be designed prior to initial construction of the proposed drawdown facilities. This plan will be a cooperative effort between the Department of Environmental Regulation and the Department of State and will consider specific problems associated with each site.

The recommended test drawdown of Lake Mare Prairie would also involve an historical/archeological survey. Upon approval of the drawdown, DER would coordinate with the Division of Archives to protect Florida's cultural resources by examining the lake bottom during the drawdown/holddown phase of the test. Although this experimental drawdown would not involve the construction of substantial pumping facilities or sedimentation basins, Archive officials may also propose a pre-drawdown survey of the surrounding area. Such a request would not affect the proposed drawdown in any manner. Therefore, no adverse impacts to potential archeological artifacts are expected during the Mare Prairie gravity drawdown.

# SECTION 6

# PUBLIC PARTICIPATION

The public participation program for the Lake Apopka Restoration Project EIS has been extensive and quite productive in soliciting comments and constructive criticism of the proposed project. In addition to the meetings, workshops and speeches outlined in the DEIS, local governmental agencies and concerned citizens have had numerous opportunities to contribute to the EIS process.

Over 600 copies of the Draft Environmental Impact Statement were distributed in early March of this year. Although most interested individuals had already reviewed and commented on the preliminary DEIS, many additional comments have since been received. These comments were instrumental in the re-evaluation of the project and helped to formulate the recommended restoration alternative as it is explained in this Final EIS.

Since the November 2, 1978, public workshop/meeting in Tavares, presentations and status reports on the Lake Apopka project have been made before the following groups:

| | | | |
|---|---|---|---|
| 1. | Florida House of Representatives - Natural Resources Committee | Tallahassee | January 9, 1979 |
| 2. | Orlando Kiwanis Club | Orlando | January 19, 1979 |
| 3. | Florida Legislature - Lake and Orange County delegates | Tallahassee | February 6, 1979 |
| 4. | Lake County Department of Pollution Control | Tavares | February 12, 1979 |
| 5. | Orlando Area Chamber of Commerce - Environmental Concerns Committee | Orlando | February 26, 1979 |

|  |  |  |  |
|---|---|---|---|
| 6. | Orlando Area 208 Advisory Committee | Altamonte Springs | April 18, 1979 |
| 7. | West Orange Chamber of Commerce | Winter Garden | April 19, 1979 |

On April 10, 1979, the public hearing for the Draft EIS was held in Tavares. This was one of the most important aspects of the entire public participation program and gave all concerned individuals an opportunity to present their comments directly to EPA and DER staff. A copy of the transcript of the public hearing is included in Section 8 of this document.

# SECTION 7

# WRITTEN COMMENTS AND QUESTIONS ON DRAFT EIS AND EPA RESPONSES

United States Department of the Interior

GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
Suite 216, Federal Building
80 N. Hughey Avenue
Orlando, Florida 32801

IN REPLY REFER TO:

March 14, 1979

Mr. John E. Hagan
Chief, E15 Branch
Environmental Protection Agency, Region 14
345 Courtland St., N. E.
Atlanta, Georgia 30308

Dear Mr. Hagan:

We have received a copy of the draft environmental impact statement for Lake Apopka along with the covering letter from Mr. John C. White. In accordance with the instructions in the covering letter, we are submitting our comments directly to you.

This letter is intended primarily to advise you of changes in wording deemed necessary to more explicitly express the meaning of the values given in the text and tables of the 1977 addendum to the 1970 report, "Hydrologic considerations in draining Lake Apopka - a preliminary analysis, 1970."

It is recognized that the net input to the lake over a specific period is represented purely by the change in storage over that period. However, the object of this analysis was to determine the amount of water that would have had to have been pumped if the drawdown had been attempted in any of the years between 1959 and 76. It was taken for granted that the cofferdam would have been in place and that the lake level would have been brought to a starting elevation of 64 feet by gravity flow by March 1st of each year as is planned for the actual drawdown.

Thus, the change in storage or net input that would have hypothetically occurred in each of the years is represented by the algebraic sum of the actual change in storage and the flow, which would have been precluded by the cofferdam, that actually occurred in Apopka - Beauclair Canal. These hypothetical net inputs are the values that are given in table 2 and represent the amount of water that would have had to have been pumped over the cofferdam in order to hold the lake to a level of 64 feet or lower during the indicated month.

Accordingly, the first sentence under Water Budget on page 30 should read as follows: Hypothetical net input of water to Lake Apopka if the flow of water out of the lake were blocked by a cofferdam is easily computed by the formula: Hypothetical net input with cofferdam in place = actual outflow through Apopka-Beauclair Canal plus any increase in lake storage minus any decrease in lake storage.

The heading of Table 2.2 should read: Mean monthly hypothetical net input to Lake Apopka with cofferdam in place between 1959 and 1976.

The heading for Table 2.3 should read: Yearly hypothetical net input to Lake Apopka with cofferdam in place, 1959-76.

These hypothetical net inputs were used to compute the volumes and rates of pumping given in table 3 of the Addendum without regard to the facts that the drawdown would increase ground-water inflow and preclude outflow to the muck farms. This disregard of increased ground-water inflow and decreased flow to the muck farms is not considered seriously detrimental to the analysis because the increase in ground-water inflow would be small relative to pump capacity and outflow to the muck farms normally occurs during dry spells when pumping capacity is not a critical factor.

Incidentally, in the introduction of the DEIS, the area of Lake Apopka is given as 51 square miles. This figure should be 48.

If there are any questions about these changes, do not hesitate to contact this office.

Sincerely yours,

Joel O. Kimrey
Subdistrict Chief

Copy to: Frederick V. Ramsey, 2280 U.S. Highway 19 N., Suite 202,
Clearwater, FL 33515
Jean Tolman, DNR Tallahassee
DC, Tallahassee

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT. CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE. FLORIDA 32201

SAJEN-EE

14 March 1979

Mr. John E. Hagan
Chief, EIS Branch
Environmental Protection Agency,
  Region IV
345 Courtland Street Northeast
Atlanta, Georgia 30308

Dear Mr. Hagan:

This is in reference to the DEIS for the Lake Apopka Restoration Project, Lake and Orange Counties, Florida.

My staff has reviewed the DEIS and offer the following comments:

a. Page viii, last paragraph, first sentence. This is in conflict with the adverse impacts and the wording, "avoid any damage" should be changed to "minimize damage" or "avoid any long-term damage."

b. Page 137 - Increased Nutrient Concentrations, paragraph 1. The DEIS states that "the process of pumping during the drawdown project is not expected to increase nutrient concentrations of Lake Apopka water, thus the quality of water entering the downstream lakes will be no worse than usual in this respect." This statement is misleading for the following reasons:

The drawoff of surface water as stated on page 134 will leave the unconsolidated ooze with its nutrient load in the lake. As the drawdown continues, the nutrients particularly at the water-soil interface will become more concentrated. Also, as a result of the increased discharge of water from Lake Apopka there will be an increase in the daily nutrient load to the downstream lakes.

The above-mentioned nutrient load can be calculated. Also, the assimilative capacity of the downstream lakes can be determined. This should be done and the pumping rate be based upon this assimilative capacity.

c. Page 137, paragraph 2. The DEIS states "Pumping, during drawdown, will decrease the time in which water flows through downstream lakes, thus reducing the interval for any time-dependent water-cleansing processes that might normally occur en route." The decreased time of flow through the lakes may result in the nutrients being delivered to Lake Ocklawaka at a faster rate. This is particularly true as the assimilative capacity of the upstream lakes are exceeded. This should be discussed. Even though those nutrients are diluted by water from Silver Springs the net load to Lake Ocklawaha will be increased.

d. Section 3, Alternatives and Their Effects. Should include an alternative to place a water level control structure across the area separating Gourd Neck Springs from the lake and maintaining the existing head so as not to overdrain the groundwater resources which would result in a temperature change of the ground.

Sincerely,

James L. Garland
JAMES L. GARLAND
Chief, Engineering Division

United States Department of the Interior

OFFICE OF THE SECRETARY

*Southeast Region / 148 International Blvd., N.E. / Atlanta, Ga. 30303*

April 24, 1979

ER-79/286

Mr. John E. Hagan, EIS Branch Chief
U. S. Environmental Protection Agency
345 Courtland Street
Atlanta, Georgia 30303

Dear Mr. Hagan:

We have reviewed the draft environmental impact statement for the Lake Apopka Restoration project, Orange and Lake Counties, Florida, as requested by your office. We offer the following comments.

## General Comments

We believe the statement is well written and is very thorough in its treatment of the environmental impacts of drawdown of Lake Apopka.

In discussion of the history of the lake and what caused the problem of hypereutrophication to occur, we believe the statement does not adequately consider or place enough emphasis on the diking by agricultural interests which separated practically the entire marsh associated with Lake Apopka to create muck farms in the 1940's. This fact had more to do with the problems that occurred in the lake than any other factor, since Florida lakes are dependent on their associated littoral zone and marshlands in order to provide productive fishery habitat and wildlife resources, as well as cleanse the waters by removing sediments in the marshes and oxidizing organic materials as water fluctuates in and out of the marshlands. A drawdown would be simple if the marsh were still there and the muck farms had not been created. This interaction of the lake and its marsh cannot be recreated under the drawdown proposed, which will limit the beneficial effects of the project.

Bureau of Mines data for Lake and Orange Counties, Florida, lists mineral production of peat and sand and gravel. According to the Bureau of Mines Mineral Industry Location System (MILS), current mineral production activity of peat and sand and gravel does occur in the immediate area of the proposed project, but not within the boundaries of Lake Apopka. We note the project does provide for continued mineral production in the immediate area of the project.

## Specific Comments

### Pages 68 and 69, Table 2.11

While the list of endangered, threatened, or rare species is very thorough, we believe these species named on the Federal list should be emphasized more. They should be discussed in some method other than simply a footnote indicating they are on the Federal list.

### Page 96, Historical/Archeological Resources

The Environmental Protection Agency (EPA) has stated that a professional archeological and historical survey of the project area will be conducted in accordance with the State Historic Preservation Officer's recommendation. We endorse this recommendation, but believe such field investigations should not wait until approval of the project. Under the requirements of the Code of Federal Regulations (36 CFR 800.4), the object is to identify historic and archeological resources in the area of potential impact that are eligible for inclusion in the National Register, and to use that information in assessing project alternatives. Enough flexibility should be left in the project design to minimize any impacts to historic and archeological sites at proposed construction sites, spoil disposal sites, pump and pipeline locations, and access roads. Therefore, the EPA should have this survey work completed as soon as possible. The results should be included, along with appropriate recommendations, in the final environmental statement.

### Page 112, Drawdown and Sediment Consolidation

We believe this section could be improved and made more balanced by citing the beneficial effect of wading bird feeding as a harvest mechanism during lake drawdown as is mentioned on page 171 in relation to the bald eagle, osprey, and wood stork.

### Page 131, Phase VII

It is noted that after restoration of Lake Apopka is completed, Lake Beauclair will be restored. The statement also should assess the need for restoration measures for Dora, Eustis, and Griffin Lakes to mitigate any adverse effects that occur during refill and holddown operations for Lake Apopka.

We appreciate the opportunity to review and comment on this draft environmental impact statement.

Sincerely,

James H. Lee

Regional Environmental Officer

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
ATLANTA, GEORGIA 30333
TELEPHONE: (404) 633-3311

April 11, 1979

Mr. John E. Hagan
Chief, EIS Branch
Environmental Protection Agency
Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30308

Dear Mr. Hagan:

We have reviewed the draft environmental impact statement for Lake Apopka Restoration Project, Lake and Orange Counties, Florida. We are responding on behalf of the Public Health Service.

We reviewed the subject report for potential vectorborne disease impacts. Our analysis of the proposed work centered on the likelihood of increased mosquito-producing habitats which would affect local mosquito control problems and also the chances for St. Louis encephalitis transmission. We have found that the foregoing adverse impacts have been considered and that no serious mosquito control problems are foreseen. However, mosquito surveillance at the lake site should be continued in order to be aware of developing vector populations.

The selected alternative appears to be the most practical solution for Lake Apopka, and potential health impacts have been adequately addressed. We commend the provisions made in regard to the public participation program and the engineering constraints provided regarding the protection of people, property, and water quality around the lake and in downstream areas.

Thank you for the opportunity of reviewing this statement. We would appreciate receiving two copies of the final statement when it is issued.

Sincerely yours,

Frank S. Lisella, Ph.D.
Chief, Environmental Affairs Group
Environmental Health Services Division
Bureau of State Services

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
REGION IV
101 MARIETTA TOWER Suite 1503
ATLANTA, GEORGIA 30323

April 10, 1979

OFFICE OF THE
Principal Regional Official

HEW-917-3-79

Mr. John E. Hagan, Chief
EIS Branch
Environmental Protection Agency, Region IV
345 Courtland Street, N. E.
Atlanta, Georgia 30308

Subject: DEIS, Lake Apopka Restoration Project, Lake and Orange Counties, Florida

Dear Mr. Hagan:

We have reviewed the subject draft Environmental Impact Statement. Based upon the data contained in the draft, it is our opinion that the proposed action will have only a minor impact upon the human environment within the scope of this Department's review. The impact statement has been adequately addressed for our comments.

Sincerely yours,

James E. Yarbrough

James E. Yarbrough
Regional Environmental Officer

cc: A. McGee
R. Goldberg

1 2 1979

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
State Office, P. O. Box 1208, Gainesville, FL 32602

April 5, 1979

Mr. John E. Hagan
Chief, EIS Branch
Environmental Protection Agency,
Region IV
345 Courtland Street, Northeast
Atlanta, Georgia 30308

Dear Mr. Hagan:

RE: Draft Environmental Impact Statement
Lake Apopka Restoration Project

We have reviewed the subject draft environmental impact statement and have no substantial comments to offer.

Sincerely,

William E Austin
William E. Austin
State Conservationist

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

*Address reply to:*
COMMANDER (dpl)
Seventh Coast Guard District
51 S.W. 1st Avenue
Miami, Fla. 33130
Phone: (305) 350-5502

16475
5 April 1979

Environmental Protection Agency,
EIS Branch
345 Courtland Street, N.E.
Atlanta, Georgia 30308

Re: Draft EIS, Lake Apopka
Restoration Project, Lake and
Orange Counties, Florida.

Dear Sir:

The U. S. Coast Guard's Seventh District Office has reviewed the above referenced project and finds no conflicts within our agency's jurisdiction.

Thank you for the opportunity to register our comments. If we may be of further assistance, please do not hesitate to contact us.

Sincerely,

E. McCARTY
Commander, U.S. Coast Guard
District Planning Officer
By direction of the Commander,
Seventh Coast Guard District

Copy to:
COMDT (G-WEP-7/73)

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
P.O. Box 1079
Tallahassee, Florida 32302

March 12, 1979

In Reply Refer To:

Mr. John E. Hagan
Chief, EIS Branch
Environmental Protection Agency
345 Courtland St. N.E.
Atlanta, Georgia

Dear Mr. Hagan:

Subject: Florida - Draft Environmental Impact Statement
Lake Apopka Restoration Project

We received your letter dated March 1, 1979 and enclosed draft environmental statement for the Lake Apopka Restoration Project, Lake and Orange Counties.

We have reviewed your environmental submission and have considered the proposed project in relation to responsibilities of this office in administering the Federal-aid highway program in Florida. Since the proposed work should not have any effect on highway transportation facilities, we have no comments concerning the proposed project.

The above finding does not in any way commit our cooperating State agency, the Florida Department of Transportation (FDOT). We assume that comments will be solicited from FDOT through Clearinghouse procedures required by Bureau of the Budget Circular A-95.

Sincerely yours,

P. E. Carpenter

P. E. Carpenter
Division Administrator

FEDERAL ENERGY REGULATORY COMMISSION
REGIONAL OFFICE
730 Peachtree Street, N. E.
Atlanta, Georgia 30308
May 3, 1979

Mr. John E. Hagan
Chief, EIS Branch
Environmental Protection Agency
Region IV
345 Courtland Street, N. E.
Atlanta, GA 30308

Dear Mr. Hagan:

This is in response to your letter dated March 1, 1979, with attachment, requesting our comments on the Draft Environmental Impact Statement for Lake Apopka Restoration Project, Lake and Orange Counties, Florida.

The Commission's principal concern in regard to developments affecting land and water resources is the possible impacts of such projects on the construction and operation of bulk electric power facilities and interstate natural gas systems.

In reviewing the study area we noted nothing that should interfere with any of the Commission's licensed hydroelectric projects. However, provision should be made to protect electrical transmission lines and natural gas pipelines in the construction area.

We appreciate the opportunity to comment on your proposed project.

Very truly yours,

Aarne O. Kauranen
Regional Engineer

MAY 4 1979

STATE OF FLORIDA

**Department of Administration**

Division of State Planning
ROOM 530 CARLTON BUILDING
TALLAHASSEE
32304
(904) 488-1115

R. G. Whittle, Jr.
STATE PLANNING DIRECTOR

Bob Graham
GOVERNOR

Jim Tait
SECRETARY OF ADMINISTRATION

April 26, 1979

RECEIVED
MAY 11 1979
DEPT. OF
ENVIRONMENTAL REGULATION

Mr. John C. White
Regional Administrator
U. S. Environmental Protection
Agency, Region IV
345 Courtland Street
Atlanta, Georgia 30308

Dear Mr. White:

Functioning as the state planning and development clearinghouse in U. S. Office of Management and Budget Circular A-95, we have reviewed the following draft environmental impact statement: Lake Apopka Restoration Project, Lake and Orange Counties, Florida, SAI 79-1511E. This document presents various alternative actions for improving the waters of Lake Apopka in order to meet Class III water standards.

During our review we referred the environmental impact statement to the following agencies, which we identified as interested: Department of Agriculture and Consumer Services, Department of Community Affairs, Department of Commerce, Department of Environmental Regulation, Department of Legal Affairs, Department of Health and Rehabilitative Services, Department of Natural Resources, Department of State, Department of Transportation, Game and Fresh Water Fish Commission, St. Johns River Water Management District, and Bureau of Land and Water Management. Agencies were requested to review the statement and comment on possible effects that actions contemplated could have on matters of their concern. Letters of comment on the statement are enclosed from: Department of Health and Rehabilitative Services, Department of Commerce, Department of Environmental Regulation, Department of Natural Resources, Game and Fresh Water Fish Commission, Bureau of Land and Water Management; the Department of Community Affairs reported by telephone with no adverse comments.

We have reviewed this document and the state agency comments thereon. Based upon this review, we support the overall concept of improving the lake's water quality by the recommended drawdown method, although a project of this magnitude has never been attempted. We suggest that if the 14 million dollars is not appropriated during the next fiscal year to implement the selected project alternative, limited drawdowns be made by the responsible agencies within their financial capabilities.

In accordance with the Council on Environmental Quality guidelines concerning statement on proposed federal actions affecting the environment, as required by the National Environmental Policy Act of 1969, and U. S. Office of Management and Budget Circular A-95, this letter, with attachments, should be appended to the final environmental impact statement on this project. Comments regarding this statement and project contained herein or attached hereto should be addressed in the statement.

We request that you forward us copies of the final environmental impact statement prepared on this project.

Sincerely,

R. G. Whittle, Jr.
Director

RGWjr:WKmb
Enclosures
cc: Mr. Charles Blair
Mr. James J. Cooney
Ms. Joan M. Heggen
Mr. Joseph W. Landers, Jr.
Mr. W. N. Lofroos
Mr. David Swafford
Mr. H. E. Wallace
Mr. Robert Williams
Mr. Jacob D. Varn

FLORIDA GAME AND FRESH WATER FISH COMMISSION

R. BERNARD PARRISH JR.
Chairman, Tallahassee

GEORGE G. MATTHEWS
Vice Chairman, Palm Beach

DONALD G. RHODES, D.D.S.
West Eau Gallie

NELSON A. ITALIANO
Tampa

CECIL C. BAILEY
Jacksonville

ROBERT M. BRANTLY, Executive Director
H. E. WALLACE, Assistant Executive Director

April 23, 1979

Mr. Loring Lovell, Chief
Bureau of Intergovernmental Relations
Department of Administration
660 Apalachee Parkway
Tallahassee, Florida

Re: SAI 79-1511E, Lake Apopka
Restoration Project, Lake &
Orange Counties, Florida

Dear Mr. Lovell:

The Office of Environmental Services of the Florida Game and Fresh Water Fish Commission has reviewed the referenced Draft Environmental Impact Statement, and offers the following comments.

We support the concept of enhancing Lakes Apopka and Beauclair through severe drawdowns, and are confident that the plan could significantly improve the water quality and habitat conditions within these lakes. We have reservations, however, regarding the degree of habitat restoration, increased recreational opportunities, and economic benefits to be derived from the project as proposed. This aquatic ecosystem has been abused for many years through destruction of the natural floodplain; agricultural, industrial, and domestic pollution; sudden, massive nutrient pulses resulting from forage fish and water hyacinth control efforts; and lake-level stabilization. The drawdowns as proposed are necessary steps toward restoration of the Oklawaha headwaters, but they will probably not provide substantial long-term benefits unless additional measures are implemented.

Water level stabilization has been a significant factor in the decline of many Florida lakes. Provision of suitable habitat for fish and wildlife, and water quality enhancement are major objectives of the restoration plan. Both of these goals are dependent on growth and maintenance of littoral vegetation. Among the benefits derived from a vegetated littoral community are the provision of protective cover for aquatic organisms; egg-deposition and emergence sites for insects, snails, and other invertebrates; spawning habitat for fishes; feeding areas for wading birds and waterfowl; stabilization of bottom sediments; vegetative assimilation of nutrients; and physical filtration of flocculents and other pollutants. Fluctuating water levels are necessary to maintain healthy vegetated littoral zones for three major reasons: first, stabilization of substrates facilitates anchoring of rooted species; second, development and distribution of lake vegetation is largely controlled by water levels prevailing during the growing season; and finally, the primary factor determining lakeward emergent plant range is the lowest water stage during the growing season. This document briefly discusses the need for fluctuating lake levels, and recommends that such a plan be adopted. We wish to stress the importance of lake-level fluctuation, and feel that implementation of the proposed drawdowns without concurrently effecting a significant annual lake fluctuation program would be a short-term improvement at best, essentially ignoring the long-term needs of the Upper Oklawaha Chain of Lakes.

Nutrient abatement is another area of major concern. The Statement discusses existing abatement programs on Lake Apopka, and we fully recognize the improvements which have been made in the nutrient budget of these lakes. There are several areas, however, where we feel additional measures are necessary if habitat and water quality are to be restored within this lake system. The muck farms adjacent to Lake Apopka include over 7,000 hectares, and have been a major nutrient source in the past. Nutrient abatement plans approved by the Florida Department of Environmental Regulation have, or will have by July, 1980, reduced the nutrient load from these farms by 25 to 65 percent, depending on the specific farm and nutrient component in question. When the pre-abatement quantity of water pumped from muck farms into Lake Apopka is considered (142.9 million cubic meters per year, or approximately 42% of the lake's annual water input), the impact of such discharge is apparent. Unfortunately, no nutrient budget data are presented in the Statement, although a Department of Pollution Control document prepared in 1972 is referenced. Because of this deficiency, we cannot comment on the adequacy of the existing nutrient abatement program, except to encourage further reduction of nutrient loading by the muck farms and other major controllable sources.

Another difficulty with the proposed plan is the rigid time schedule necessitated by a committment to provide freeze protection to citrus groves near the lake. The holddown would occur during the rainy season, and frequent heavy rainfall could significantly affect the project's success. If such a rigid timetable must be followed, we recommend development of a contingency plan to reflood the lake to 64 feet m.s.l. until the following March, and then drawdown to 58 feet m.s.l. the following year. Other alternatives could include compensating grove owners for certain losses, or permitting temporary freeze-protection methods normally banned because of air-pollution statutes. Under any restoration plan, reflooding should be delayed until extensive monitoring indicates that consolidated sediments will not appreciably become resuspended. While any such contingency plan would substantially increase the project costs, it may be preferable to losing 14 million dollars or more because of an unusually wet summer.

According to the Statement, nearly all construction sites would be dismantled and returned to their original stature following the drawdowns. In those areas where these sites could be used as work facilities for future lake management projects or investigations, as monitoring stations for water quality or habitat improvement studies, or where they would provide a more suitable substrate than the sediments they replaced, we would not object to leaving such sites at least partially unreclaimed.

The growth of terrestrial vegetation will have the beneficial effect of binding sediments and helping to prevent their resuspension upon flooding. As stated in the document, however, this same vegetation may retard compaction and dessication of sediments by shading the lake bottom. Upon reflooding, this vegetation will die and could cause significant algae blooms which would inhibit growth of emergent or submerged vegetation.

Persistent algae blooms or uncontrolled growth of aquatic plants could occur upon reflooding, as discussed in the document. This, in turn, could lead to an overabundance of rough fishes as presently exists in Lake Apopka. Plans to harvest such undesirable species should be developed to provide an additional nutrient removal.

The extreme depth of some silt and muck deposits in Lake Apopka could produce a public hazard during the drawdown if a firm crust developed over deep, unconsolidated sediments. Such areas should be posted to prevent crust-failure related accidents.

Because a project of this magnitude has never been attempted, there are insufficient data to accurately predict the outcome of its implementation. The proposed plan, however, would undoubtably improve the habitat and water quality within these lakes, and would provide an invaluable opportunity for future investigation and expansion of the scientific literature related to drawdowns and lake restoration. Unfortunately, the flexibility needed to realize maximum benefits from the project is limited by financial constraints and the necessity for citrus grove protection. Within these restrictions, we feel the proposed plan offers the most reasonable method for enhancement of Lakes Apopka and Beauclair, and ultimately, the entire Upper Oklawaha Chain of Lakes. We appreciate the opportunity to review this E.I.S., and look forward to working with the Department of Environmental Regulation on this project.

Please call me if I can be of further assistance.

Sincerely,

H. E. Wallace
Assistant Executive Director

HEW/RF/rs

STATE OF FLORIDA

DEPARTMENT OF HEALTH AND REHABILITATIVE SERVICES

PROJECT NOTIFICATION AND REVIEW SYSTEM

RECOMMENDATION

DIVISION OF STATE [illegible] NING,
RECEIVED
1979

Office of the
Secretary

Date: March 30, 1979

MEMORANDUM

SUBJECT: NOTIFICATION OF INTENT TO APPLY FOR FEDERAL FUNDS

TO: Chief, Bureau of Intergovernmental Relations, State Planning and Development Clearinghouse

FROM: Director, Office of Health and Social Services Policy Development
Department of Health and Rehabilitative Services

BY: Harold L. Davidson, Department Coordinator for PNRS

REF. NO: DHRS ____________ SPDC (SAI) 79-1511E

TITLE Lake Apopka Restoration Project

APPLICANT U.S. Environmental Protection Agency

☒ The project is consistent with the goals and objectives of the Department of Health and Rehabilitative Services. Favorable action is recommended.

☐ Substantive comments have been received and are summarized in the attached.

☐ Full application is requested

☐ Conference with applicant is requested.

☐ The project is not consistent with the goals and objectives of the Department of Health and Rehabilitative Services. Approval is not recommended for reasons described in the attached comments.

Attachment(s)

Department of Administration

Division of State Planning
Room 530 Carlton Building
TALLAHASSEE
32304
(904) 488-2371

G.Whittle, Jr.
ATE PLANNING DIRECTOR

Reubin O'D. Askew
GOVERNOR

Wallace W. Henderson
SECRETARY OF ADMINISTRATION

[illegible] STATE
Bureau Of
Intergovernmental Rela
MAR 23 1979
RECEIVED
SAI NO. ____

RECEIVED
MAR 15 1979
Department of Commerce
Administrative Services

**TO:** SECRETARY
Department of Commerce
510 Collins Building
Tallahassee, Florida 32304

**DATE:** 3.13.79

**DUE DATE:** 3.27.79

**SUBJECT SAI:** 79-1511E

**ATT:** ____

**FROM:** Bureau of Intergovernmental Relations

The attached "424 Preapplication" serving as notification of intent to apply for federal assistance is being referred to your agency for review and comment. Your review and comments should address themselves to the extent to verify that the project(s) is/are consistent with or contributed to the fulfillment of your agency's plans or the achievement of your projects, programs and objectives.

If further information is required, you are urged to telephone the contact person named on the preapplication form. If a conference seems necessary, or if you wish to review the entire application, contact this office by telephone as soon as possible. Please check the appropriate box, attach any comments on your agency's stationery and return to BIGR or telephone by the above due date. If we do not receive a response by the due date, we will assume your agency has no adverse comments. In both telephone conversation and written correspondence, please refer to the SAI Number.

Sincerely,

Loring Lovell
Loring Lovell, Chief
Bureau of Intergovernmental Relations

Enclosure

*******************************************************************************

TO: Bureau of Intergovernmental Relations

ROM: Department of Commerce

UBJECT SAI: 79-1511E

No Comment ☒ Comments Attached ☐

ivision/Bureau of Economic Analysis

eviewer ____ Date 3/21/79

TWIN TOWERS OFFICE BUILDING
2600 BLAIR STONE ROAD
TALLAHASSEE, FLORIDA 32301

BOB GRAHAM
GOVERNOR

JACOB D. VARN
SECRETARY

STATE OF FLORIDA
**DEPARTMENT OF ENVIRONMENTAL REGULATION**

Intergovernmental
APR 23 1979
RECEIVED
SAI NO.

April 19, 1979

Loring Lovell, Chief
Bureau of Intergovernmental
Relations
Department of Administration
Division of State Planning
Room 530, Carlton Building
Tallahassee, Florida 32301

Dear Mr. Lovell:

Lake Apopka Restoration Project,
Environmental Impact Statement,
Lake and Orange Counties, Florida,
SAI No. 79-1511E

As you may know the Department of Environmental Regulation has been extensively involved in the development of the proposed restoration program for Lake Apopka as it is outlined in the above referenced Environmental Impact Statement. Following comprehensive investigation it has become apparent that lake restoration efforts would necessitate a complex and major program effort if any degree of success is to be anticipated. The Department is pursuing the completion of the final EIS at this time, however, commencement of work is not forseen in the near future.

We appreciate the opportunity to comment on this advance notification.

Sincerely,

Harry A. Dail

Harry A. Dail
Environmental Specialist
Intergovernmental Programs
Review Section

HAD/mk
cc: Suzanne Walker

STATE OF FLORIDA

# Department of Administration

Division of State Planning
660 Apalachee Parkway - IBM Building
TALLAHASSEE
32304
(904) 488-2371

G. Whittle, Jr.
TE PLANNING DIRECTOR

Reubin O'D. Askew
GOVERNOR

Lt. Gov. J. H. "Jim" Williams
SECRETARY OF ADMINISTRATION

Intergovernmental Relations
MAR 20 1979
RECEIVED

TO: Mr. Harmon Shields
Department of Natural Resources
202 Blount Street, Crown Building
Tallahassee, Florida 32304

DATE: 3-13-79

DUE DATE: 3-27-79

RECEIVED
MAR 14 1979
DEPARTMENT OF
NATURAL RESOURCES

FROM: Bureau of Intergovernmental Relations

SUBJECT: SAI: 79-1511E

The attached "Advance Notification" of intent to apply for federal assistance is being referred to your agency for review and comments. Your review and comments should address themselves to the extent to which the project is consistent with or contributes to the fulfillment of your agency's plans or the achievement of your projects, programs and objectives.

If further information is required, you are urged to telephone the contact person named on the notification form. If a conference seems necessary, or if you wish to review the entire application, contact this office by telephone as soon as possible. If you have no adverse comments, you may wish to report such by telephone. Please check the appropriate box, attach any comments on your agency's stationery, and return to this office or telephone by the above due date. If we do not receive a response by the due date, we will assume your agency has no adverse comments. In both telephone conversation and written correspondence, please refer to the SAI number.

Sincerely,

Loring Lovell, Chief
Bureau of Intergovernmental Relations

Enclosure

************************************************************************

TO: Bureau of Intergovernmental Relations
FROM: Department of Natural Resources
SUBJECT: Project Review and Comments, SAI: 79-1511E

☒ No Comments ☐ Comments Attached

Signature: James B. Smith Date: March 27, 1979

Title: Administrative Assistant

BIT

**Division of State Planning**

660 Apalachee Parkway • IBM Building

TALLAHASSEE

32304

(904) 488-2371

le, Jr.
RECTOR

Reubin O'D. Askew
GOVERNOR

Lt. Gov. J. H. "Jim" Williams
SECRETARY OF ADMINISTRATION

MAR 15 1979
RECEIVED

RECEIVED
MAR 14 1979
BUREAU OF LAND
& WATER MANAGEMENT

O: Jim May
Bureau of Land and Water
Management
Carlton Building
Tallahassee, Florida 32304

DATE: 3-13-79

DUE DATE: 3-27-79

ROM: Bureau of Intergovernmental Relations

BJECT: SAI: 79-1511E

The attached notification of intent to apply for federal assistance is
ing referred to your agency for review and comments. Your review and comments
ould address themselves to the extent to which the project is consistent with
contributes to the fulfillment of your agency's plans or the achievement of
ur projects, programs and objectives.

If further information is required, you are urged to telephone the contact
rson named on the notification form. If a conference seems necessary, or if
u wish to review the entire application, contact this office by telephone as
on as possible. If you have no adverse comments, you may wish to report such
telephone. Please check the appropriate box, attach any comments on your
ency's stationery, and return to DIGR or telephone by the above date. If we
not receive a response by the due date, we will assume your agency has no
verse comments. In both telephone conversation and written correspondence,
ease refer to the SAI number.

Sincerely,

Loring Lovell, Chief
Bureau of Intergovernmental Relations

losure

******************************************************************

Bureau of Intergovernmental Relations

M:

JECT: Project Review and Comments, SAI: 79-1511E

☑ No Comments ☐ Comments Attached

nature: Gilbert Barkinton, J

Senior Planner

Date: 3-15-79

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**City of Leesburg**
COMMISSIONER-MANAGER FORM OF GOVERNMENT
P.O. BOX 630
LEESBURG, FLORIDA 32748

MAYOR-COMMISSIONER
CHARLES C. STRICKLAND

COMMISSIONERS
JACK K. BRADLEY
BURTON BROWN
CHARLES W. GREGG
JOE H. SELLERS

CALVIN E. GLIDEWELL, CITY MANAGER
JAMES C. SCHUSTER, CITY CLERK/FIN. DIR.

April 9, 1979

U. S. Environmental
Protection Agency
Region IV
245 Courtland Street
Atlanta, Georgia 30308

Re: Comments concerning Environmental Impact Statement for the Lake Apopka Restoration Project Lake and Orange Counties, Florida.

Dear Sir:

The City of Leesburg would like to take this opportunity to comment on the above draft concerning the Lake Apopka drawdown. After review of the Environmental Impact Statement we find that contradictions exist concerning the effects to Lake Griffin and Lake Harris.

Contained within the summary of the Statement, three adverse effects are outlined to downstream lakes, which are:

1. Phytoplankton populations in downstream lakes may increase during drawdown and holddown.
2. Fish will die as they become extremely concentrated in the remaining pools of water. Downstream fish kills are possible but not expected.
3. The water quality of downstream lakes may be temporarily degraded due to increased nutrient levels and reduced dissolved oxygen concentrations.

We have found the contradictions existing on pages 114 and 115 under Section 4, the subsection titled Constraints states that eleven constraints will be enforced upon the drawdown and of these, number 6 requires that no backflow from Lake Harris will occur and number 5 concerns water quality, yet the effect to Lake Griffin is not mentioned.

We contend that Lake Griffin must be protected by the constraints to prevent further degradation.

We hope that you will address these points and adjust your program accordingly. Thank you for the opportunity to review the Environmental Impact Statement.

Very truly yours

Calvin E. Glidewell
City Manager

lmh

April 24, 1979

David C. Baldwin
811 Cascade Avenue
Leesburg, FL 32748

John E. Hagan
Chief, EIS Branch
Environmental Protection Agency
Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30308

Dear Mr. Hagan:

This letter is in reference to the proposed Lake Apopka Restoration Project. I am presently employed as an Environmental Chemist and hold a B.S. in Microbiology and shortly will have a M.S. in Microbiology. The following are my comments and questions on the proposed project:

My first concern is the quality of the water that is to be pumped from Lake Apopka into Lake Beauclair, to Lake Dora, Lake Eustis, Little Lake Harris and subsequently to all the lower lakes of the chain. It is apparent that the quality of Lake Apopka water is poor, as is. It is marginal if the receiving waters can handle the load of nutrients existing now in Lake Apopka. During the draw down process, the muck layer will be disturbed releasing more of these nutrients in the water. The disturbance will come not only from hydrulic movement, but as the level is lower, the muck layer becomes closer to surface and subject to disturbance from wind movement. Consequently, the nutrient levels in the later stages of draw down will be considerably higher. The mere fact of the incorporation of a sedimentation basin displays concern for the disturbance of the muck bottom. It is my opinion that the receiving lakes cannot handle that load. Are you (at EPA) under the impression that they can?

After reading the impact study draft and attending the last two meetings (hearing) on the project, there has been the complete avoidance mentioning the percent chance of success of the project. The differences in the muck in Lake Apopka does not lend itself to complete crust formation on the exposed bottom. Unless the crust is formed on a major percentage of the bottom, there isn't much hope for success. It has also been brought to my attention that the plants that will grow and become rooted during draw down. When the refill process occurs, they will tend to float and bring with them the crust.

Without the crust formation, Lake Apopka will soon be back in the same condition. With the risks involved to the surrounding environment and the cost of the project, there should be almost absolute success in the project. No one wants to give any guarantees. If this project fails, any future lake restoration projects haven't much hope for approval.

Much effort has thus far been spent on this project and the desire to restore Lake Apopka is sound. But I believe that the proposed draw down is dangerous to the surrounding environment (receiving waters) and the chances of success poor. Time should be invested into further research and investigation of this and the other alternatives. The project is too important to proceed with such a shaky solution.

Thank you for listening and I am looking forward to your comments.

Sincerely,

David C. Baldwin

DCB:dlw

April 27, 1979

Mr. John Hagan
345 Courtland St N.E.
Atlanta, Ga 30308

Dear Sir,  Re: Lake Apopka Drawdown

The only thing that worries me about the drawdown is the affect on the large Spring at the south end of the lake. It should be protected during the drawdown.

If the drawdown lowers the spring and thus makes it gush forth more water, so that after the lake is refilled the spring might not have the force it had before the drawdown then that would be very bad. The lake then ~~I~~ would probably become a bunch of puddles + be ~~of~~ worse off than it is now.

So unless plans are made to protect the Spring, my husband + I would be against the drawdown.

We are residents of Montverde, + live on the west shore of Lake Apopka.

Sincerely
June Ley
Bill Ley

P.O. Box #73
Montverde Fl 32756

**ERIC M. HOOPER**
11 E. LAUREL STREET
APOPKA, FLORIDA 32703

April 24, 1979

John E. Hagan
EPA Region IV
343 Courtland Street N.E.
Atlanta, Georgia 30308

Dear Sir:

On April 10, 1979, I attended a hearing on the drainage plan for Lake Apopka. I was told to address any remarks concerning this plan to you.

I have owned land on the north shore of Lake Apopka for thirty years. During this time I have seen governmental experiments such as hyacinth control, fish kills, partial drainage and others tried. I believe all these experiments have been wasted tax payer monies with nothing but adverse effects on the condition of the lake.

Without lengthy details to you I would like to express my desire that no Federal money be spent on this huge experiment of draining this large lake. I believe the money could be used much more wisely on smaller experiments. At this time of expressed governmental concern over inflation control I do not think my tax money, both State and Federal, should be wasted on a project with no known positive results to be realized. I mention one example of this type experiment, Lake Tohopekaliga in Osceola County. This lake was drained and is now ready to be drained again.

As a land owner and tax payer I request that this project not be funded in any part by your agency.

Sincerely,

E M Hooper

E.M. Hooper

EMH/ch

LEWIS C. FARNER PHONE (904) 343-3131

**TAVARES MOBILE HOME PARK**
112 DONNA STREET
TAVARES, FLORIDA 32778

April 19, 1979

Re: Lake Apopka Restoration
Project

Mr. John E. Hagen
Chief, EIS Branch
EPA, Region IV
345 Courtland St. NE
Atlanta, Georgia 30308

Dear Mr. Hagan;

As owner of Tavares Mobile Home Park, located on Lake Dora and at the entrance of the Dora Canal, I am very much interested in, and concerned about the Lake Apopka Restoration Project.

We have attended several of the hearings and have read the draft of the Environmental Impact Statement. Both have not addressed what, I think will be a serious problem for me. That is the erosion caused by increased water flow on the approximately 1800 feet of shoreline just prior to entering the canal .

Any problems caused by the electric pumps just across the canal, and the pipeline running parellel to the rear of our park can be overcome and will be temporary. The loss of more property to erosion will be permanent and costly.

My only other comment would be that I agree with the spokeswoman who recently commented to the Sentinel newspaperthat "if the project is not funded, the best thing to do would be to close the Apopka Canal." It makes sense, if the muck farmers and grove owners don't completely stop from dumping effluent in the lake. What they do , is the only explanation for the drastic changes in the water qualities of Lake Dora, For weeks it will be clearing and the bottom visible many feet rom shore, but overnight it changes to a filthy, murky, mess.

Thank you for the opportunity to comment.

Sincerely,

Lewis C. Farner

Lewis C. Farner

**CLONTS FARMS, INC.**

P. O. BOX 490 • OVIEDO, FLORIDA 32765 • PHONE: 305-365-3351

John E. Hagan
Chief, EIS Branch
EPA, Region IV
345 Courtland Street, NE
Atlanta, Georgia 30308

Dear Mr. Hagan:

I am a muck farmer and a member of the Citizens' Review Committee and would like to comment on the EPA Environmental Impact Statement on the Lake Apopka Restoration Project. The authors have attempted to address the needs of the muck farms that border Lake Apopka on pages 13, 116, 159, and 126, stating that they must have irrigation water and dike protection during the draw-down.

Actually if adequate dike protection is given during draw-down, the farms will have adequate irrigation water.

I do not think the authors have properly assessed the need to hold the water level at near low normal during draw-down to hold the pressure against the dike and at the same time provide moisture so that it will not dry out. Drying out would make it vulnerable to cracking and a tendency to float when the lake pressure is re-applied.

On page 126 under "E. Muck Farm Irrigation" is stated "The plan calls for cleaning and enlarging some of the existing canals and repairing breaks and low spots in the Willows Dike to an elevation of not more than 19.8 m (65 ft) msl." No mention is made of the height of the water retained between the two structures. I maintain that to be on the safe side the water should be held against the muck farm dike at not less than 66 ft. msl. Then the dike would have to be built higher and stronger than is specified in this report. There is no Willows Dike. They refer instead to that section of the original muck bed between the bar pit that was dug outside of the muck dike.

**CLONTS FARMS, INC.**

P. O. BOX 490 • OVIEDO, FLORIDA 32765 • PHONE: 305-365-3351

No mention is made about the disastrous breaks that occurred in the different dikes adjacent to the lake in the spring of 1957 following a period of low water and after the lake had risen to 68 ft. following the closing of the locks at Beauclair. At one time 26 dredge lines were busy repairing numerous breaks in at least four different sections of the dike. These involved Duda, Frank's farm and drainage district 2 dikes.

I would like assurance that the second dike outside of the present dike be built to an elevation of 68 ft. above msl and that a level of water between the two dikes be maintained at 66 ft. msl.

I would also like to be assured that the draw-down would be immediately discontinued if a break in the second dike occurs. Loss of irrigation water during spring would be disastrous to the muck farmers.

Yours truly,

W Rex Clonts
W. Rex Clonts
President

WRC/tc

BROMWELL ENGINEERING

April 19, 1979

Mr. John Hagan
Chief, EIS Branch
EPA, Region IV
345 Courtland St. NE
Atlanta, Georgia 30308

Dear Mr. Hagan:

The public hearing on the draft EIS for Lake Apopka Restoration brought out some interesting comments which have a bearing on my suggested alternative approach to the project. The opposition voiced at the hearing came from:

1. The citrus owners who felt that they were not being sufficiently protected.
2. Land owners on downstream lakes who don't want any water quality degradation.
3. Taxpayers who feel that the cost is too high.

These people question whether the predicted results make the project worthwhile.

By constructing dikes to permit a drawdown on one section of the lake at a time, not only are all of the above problems dealt with, but improved restoration should be attained. The dikes would permit normal levels to be maintained in major portions of the lake during sectional drawdown. The most critical lake areas for citrus could be scheduled during warmer months.

There would not be the need to pump the entire lake down rapidly. This would relieve the flood of water into downstream lakes and eliminate the dams, pipeline and pumps in the other lakes. Only during drawdown of the first section would the discharge flow increase and the rate and timing of this could be made to accommodate canal capacity.

APR 23 1979

The earthen dikes could be constructed by dredging suitable material from the lake bottom below the muck. Although a detailed engineering design would be required, initial estimates indicate the dikes might cost $2,000,000. This cost could increase by a factor of 2 or 3 and still result in savings of $12,000,000 to $15,000,000 over the recommended action. The other costs such as pumping, engineering, and maintenance are estimated to be in the $1-2 million range for the sectional dike concept, leading to a total cost in the range of $3-4 million.

The other big advantage of this alternative approach is the likelihood of doing a better job of muck consolidation. It is felt that there is a good chance of lowering the water level in the section being treated below elevation 58 feet MSL. This would result in producing a strong bottom crust on more than 30% of the lake bottom. It would reduce the 30% area that would be unimproved with the procedure recommendations in the EIS. It may even be possible to use the dredge to transfer heavy muck from the deep holes to the muck farms to revitalize the soil.

Vegetation is expected to grow on the exposed lake bottom. Although this may create debris and disturbance of the consolidated muck upon refilling, harvesting is not possible with the soft bottom left with the original scheme. This alternative proposal should provide enough firm lake bottom to allow coping with vegetation prior to refilling.

The initial limited drawdown that would result from this alternative would provide many of the answers on procedures and schedules to use to optimize restoration. Time and cost constraints will not permit such additional information to be developed with the EIS project format.

As was mentioned in the hearing, this is not the time and place to criticize, but to offer constructive suggestions. The environmental studies and restoration analyses in the EIS are very good. I feel that if this background information can be used to engineer a better job for less money and less potential impacts on the area, the restoration project will be worth undertaking.

Sincerely,

Neil R. Greenwood, P. E.

NRG:se

c.c. State of Florida
DER
Tallahassee, Florida

Al Stewart
2603 N. Indian River Drive
Cocoa, Florida 32922

RECEIVED
APR 26 1979
APR 16 1979
DEPT. OF
ENVIRONMENTAL REGULATION

April 12, 1979

John E. Hagan
Chief, EIS Branch
EPA, Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30308

Lake Apopka Restoration

Dear Mr. Hagan:

As an Environmental Engineer registered as a Professional Engineer in the State of Florida and as a consultant who has been actively involved in water resource management and environmental planning for almost five years, I feel that I may be classified as somewhat more than a layman in the field of lake restoration. Working for Dawkins & Associates, Inc. in Orlando, I was the project manager for a lake restoration study on Lake Holden. I have been involved in water quality studies around the middle St. John's River and estuarine areas around Tampa Bay, Pasco County and Duval County. I have also done hydrological studies and ground water quality evaluations in Hillsborough and Polk Counties. I have been intensively involved for over two years with the use of water hyacinths for nutrient removal in wastewater and hypereutrophic natural waters. Presently I am project manager for a hyacinth demonstration project for the City of Lakeland and Polk County Florida. You may obtain a detailed history of this project and the events leading to it from Mr. Jim Wang or Mr. Gary Lubin, who are with the Florida 201 Branch of Region IV, EPA.

I might add that I have been a contributing author in two books recently published by Ann Arbor Science (Stormwater Management and Biological Nutrient Removal). In addition I have presented papers to a joint AWWA-WPCF journal on phosphorus dynamics in sediments of Florida lakes, to the Florida Association for Water Quality Control, Inc. on the use of vascular plant for water resource management, and recently to a professional seminar at the University of Central Florida on the progress of the Lakeland Hyacinth Demonstration Project.

I do not present all of this to you for the purpose of building my own ego, but rather to show you that what I present might have some credability. Up till now my suggestions have been subjected to ridicule and apparent bias. This suggestion has been basically to approach the Lake Apopka restoration in terms of natural energetics, using water hyacinths for removal and recovery of stored nutrients in the lake rather than expending energy by pumping or "fixing" these stored nutrients by drawdown, recovering nothing in return, and at the same time jeopardizing the water quality of down stream lakes.

RECEIVED
APR 26 1979
PERMIT

Any slight familiarity of Cybernetics, especially as related to the trophic dynamic concept as discussed by Lindeman (1942), Patten (1959), Odum (1957), Odum (1964), Strumm and Strumm-Zollinger (1971) and many others, should lead one to the logical conclusion that the concept of stabilization of a lake ecosystem through the controlled use of aquatic vascular plants is worth consideration. Upon presenting some of my ideas to FDER, I came to learn how naive I really was in expecting any form of objectivity or genuine competency to emerge from their review. Enclosed herein is a set of communications I have had with FDER relating to the Lake Apopka restoration. Please understand that I have worked on this concept as a private citizen and not as a representative of Dawkins & Associates, Inc. All of the data is extremely preliminary, as I have worked strictly on a volunteer basis. I do not suggest that EPA and FDER immediately put 15,000 acres of hyacinths on Lake Apopka. However, a demonstration project appears more warranted and reasonable. I must ask that this approach be evaluated as a concept not as a detailed plan, and that the evaluation be made by such experts as H. T. Odum (Univ. of Fla.), D. P. Larsen or someone of equal stature connected with your Corvallis, Oregon NES Branch, Dr. L. Bagnall (Univ. of Fla.), or C. F. Musil and C. M. Breen (Univ. of Natal, Pietermaritzburg, South Africa). Not only will these people be capable of objectively reviewing the concept, but they will undoubtedly be able to contribute greatly to the overall project.

There is a possible opportunity here to move the clean lakes program away from the beauracratic ploy which it appears to be at this time into a viable, useful program that has some bearing upon the nation's water quality and upon the quality of life of the American people. Thank you for the attention given this matter.

Sincerely,

E. A. Stewart III

cc: Jake Varn (FDER, Tallahassee)

Enclosures:

References:
Lindeman, R. L. "The Trophic-Dynamic Aspect of Ecology"
Ecology 23(1942); 399=418

Odum, E. P. "The Study of Ecosystem Development" Science 164 (1969): 262-270

Odum, H. T. "Trophic Structure and Productivity of Silver Springs, Florida" Ecological Monographs 27 (1957): 55-112

Patten, B. C. "An Introduction to the Cybernetics of the Ecosystem: The Trophic-Dynamic Concept" Ecology 40 (1959): 221-235

Strumm, W. and Strumm-Zollinger, E. "Chemostasis and Homeostasis in Aquatic Ecosystems; Principles in Water Pollution Control" in Nonequilibrium Systems in Natural Water Chemistry, pp. 1-29 Edited by R. F. Gould, Washington D. C.; American Chemical Society, 1971.

**MAGUIRE, VOORHIS & WELLS, P. A.**
ATTORNEYS AT LAW

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R. F. MAGUIRE (1890-1960)
H. M. VOORHIS (1889-1973)
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T. R. BROWN
R. T. WILSON
J. L. BUILDER, JR.
W. B. WILSON
J. E. SLATER
J. M. CORRIGAN
L. D. YATES, JR.
S. J. JOHNSON

C. D. MOTES
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W. M. CLIFFORD
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A. G. NEFF
A. L. CAMP
C. J. WEISS
L. J. TOWNSEND
J. R. SIMPSON, JR.
M. G. WILLIAMSON

M. W. WELLS
OF COUNSEL

April 24, 1979

D. S. R.
Water Resources Management

Mr. John E. Hagan
Chief, EIS Branch
EPA Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30308

RE: Lake Apopka Restoration Project, Lake and Orange Counties, Florida - Additional Comments to Environmental Impact Statement

Dear Mr. Hagan:

A substantial fish kill will occur with draw down unless the fish are removed from the lake at or prior to draw down. At one place in the EIS report (couldn't locate page in preparation of this letter) it is noted that during one prior fish kill, more pollution of the lake occurred from the fish kill than the total pollution caused by the City of Winter Garden's sewer plant in all of its years of operation. The report suggests harvesting of fish during draw down but no plan of harvest of rough fish is incorporated in the proposed budget. There is reference to commercial fish harvest on page C-8.

Terrestrial vegetation will grow on the lake bottom during the period of draw down (page 112 EIS) and harvesting of this vegetation is suggested (page 113 EIS) but is not incorporated in the proposed budget. No facts are incorporated in the report as to the difficulty of operating a harvesting machine on the solidified muck bottom of the lake.

The EIS report fails to address the fundamental question of whether or not the draw down plan is guaranteed to raise the quality of water in Lake Apopka to meetClass III standards. If no guaranty is to be made by the governmental agencies, the final report should clearly set out in the summary and in the body the percentage chance of success of draw down being successful in restoring the lake.

The final report should incorporate in its summary and in the body of the report a more adequate explanation of why there will not be "adverse agricultural effects" of freeze damage because the "engineering firm has manipulated the draw down schedule to an

Code, or below existing conditions." All the downstream lakes including Lake Griffin, are included under this constraint. Therefore, there is no contradiction, and Lake Griffin will be protected.

Individuals

14. Response to David C. Baldwin:

As previously stated in the DEIS, nutrient loadings to downstream lakes may increase during drawdown and holddown. However, this effect will be temporary, and when Lake Apopka is restored the entire chain of lakes will receive, through flushing, water of improved quality. Water quality in these lakes will be monitored during the project, and if standards are exceeded, pumping will be halted until the problem can be corrected. Other biologists have expressed concerns about excessive nutrient loadings to the downstream lakes during the project. Therefore, although it is felt these effects will be insignificant, the Final EIS recommends further studies to quantify these impacts. Further discussion of this concern can be found in the responses to the Army Corps of Engineers and the Department of the Interior.

No probability of success for the project has been given to date. This topic has not been omitted through oversight. Rather, the current data on lake drawdowns vary considerably, and success rate is dependent on numerous factors such as degree of muck consolidation, weather conditions, and construction schedules. In addition, because of the unknowns involved in this project, the ultimate benefits of this drawdown are not absolutely predictable. A lake restoration of this magnitude has never been attempted and as studies continue, an increasing number of inherent problems are recognized. A test drawdown of Lake Mare Prairie has been proposed to answer some of these questions. It is anticipated that the studies recommended in this Final EIS will eventually produce data which will permit the calculation of a probability of success.

Crust formation of the exposed lake bottom will occur over 70% of the 124 $km^2$ lake bed. Of this amount, 30% will form a firm crust and 40% will show improved firmness. The remaining 30% of the lake bottom will not be consolidated. It is this unconsolidated portion that has caused great concern over the success of the project (see Section 4 for further details). Some terrestrial vegetation will uproot as the lake is refilled, but the amount of muck disturbed in this manner is insignificant compared to the 30% that may not be consolidated at all through drawdown.

Your suggestion for further research into the specific effects of lake drawdowns is well received. The Final EIS recognizes the deficiencies in available data and recommends implementation of the drawdown only after these biological and chemical concerns have been more thoroughly analyzed. Such studies will permit a more accurate prediction of the adverse effects of the drawdown on Lake Apopka and the downstream lakes.

15. Response to June and Bill Ley:
As Lake Apopka is lowered during drawdown, Gourd Neck Springs will increase its flow rate, which will cause a drawdown of the Floridan Aquifer's potentiometric surface. As explained on page 158 of the DEIS, RSB&W estimates that the maximum decline in the potentiometric surface will be 2.7 m (9.0 ft) at the springs and 1.1 m (3.6 ft) approximately 1.6 km (1 mi) from the springs. Also, as the lake level declines, the differential in heads between the lake and the Floridan Aquifer will cause an upward flow into the lake. This leakage effect will be smaller than that from the increased flow of the springs. In other words, Gourd Neck Springs will have a heavier flow during drawdown which will lead to a slight decrease in the water level in the Floridan Aquifer. When the lake is refilled, the water level in the aquifer will return to normal as it is recharged or filled from other sources, such as rainfall. When the water level in the aquifer reaches pre-drawdown levels, Gourd Neck Springs will again have its original flow rate. Therefore, the

hydrological effects caused by the project would be temporary and relatively insignificant. No additional plans for "protecting" the springs are necessary. The response to the Corp of Engineers further explains the benefits of not restricting flow from the springs.

16. Response to E. M. Hooper:

It is true that a lake of this size has never been restored before, nor has any attempt been made to draw down and refill such enormous quantities of water within such a restricted time frame. However, even though some effects of the drawdown have not been specifically quantified, benefits will be realized from the drawdown. Analyses of natural and man-induced drawdown have shown that such actions increase littoral vegetation, improve water quality, and enhance game fish populations (see letter from FG&FWFC, pages 77-80).

The Lake Tohopekaliga experiment to which you refer was conducted in 1971 mainly to reverse environmental degradation of the lake. Following this drawdown, the littoral zone vegetation increased by 16% from 3642 hectares to 4249 hectares (9,000 acres to 10,500 acres), game fish values increased by 37%, and benthic macroinvertebrates increased 3 or 4 fold in both littoral and limnetic zones. Drawdowns have shown that proper management levels can reestablish a healthy lake ecosystem. Nutrients are "channeled into more stable organic energy forms, leading to increased sportfish production and longer maintenance of high water quality "(FG&FWFC, 1974).

The major problem with the drawdown restoration of Lake Tohopekaliga was that no nutrient abatement program was implemented. In fact, all five of the sewage treatment plants discharging into the lake increased their flows after the drawdown. These effluents were extremely nutrient-rich and were in a form immediately available for biological assimilation. Florida Game and Fresh Water Fish Commission (1974) records indicate that from 1971 to 1974, sewage plant discharges to Lake Toho increased 51.9%, to nearly 5 billion gallons annually. This increase in nutrients has degraded water quality in the lake to the extent that another major fluctuation in water level is necessary.

The drawdown technique does yield positive results, and it is expected that these improvements will occur in Lake Apopka following the proposed project. However, since Apopka has such extensive deposits of muck and nutrients, it is not known whether this one-time extreme drawdown is sufficient to permanently restore the lake. Certain aspects of the drawdown should be more thoroughly investigated prior to any implementation. To obtain a more detailed analysis of the effects of a drawdown of this magnitude, a drawdown of a smaller lake similar to Lake Apopka has been proposed in this document. These additional studies should produce information that could quantify the various effects of the project. Thus, although your opinion on expected benefits from the drawdown does not concur with the findings of this report, your opposition to funding the project is acknowledged.

17. Response to Lewis C. Farner:
Protection for the environmentally sensitive Dora Canal is provided by constraints number 3 and 4 on page 116 of the DEIS. Since the Dora Canal can only handle up to 757 $m^3$/min (200,000 gpm), the design includes the bypass transmission main through Tavares. This pipeline will shunt the additional flow around the Dora Canal, protecting it from damaging flows.

The engineers, in their final design, have calculated that maximum velocities of approximately 36.6 m/min (2.0 ft/sec) will occur in the Dora Canal. More specifically, during drawdown the flow will be about 33.7 m/min (1.84 ft/sec) and during holddown approximately 23.6 m/min (1.29 ft/sec). These velocities are comparable with those achieved during the 1971 partial drawdown of Lake Apopka (Hahn, 1977). If the property in question was not eroded at that time, there is no reason to believe it will be adversely affected during this proposed project. The engineers are confident these

It should also be realized that Lake Apopka is not the only contributor of pollutants and nutrients to downstream lakes. Each of these lakes is subject to urban runoff and other nonpoint source pollution from its own watershed. Damming the Apopka-Beauclair Canal would reduce flow through the lakes from upstream while the surrounding watershed continues to contribute pollutants at the current rate. Eventually this could lead to a greater concentration of pollutants and nutrients in these lakes and increased detention times. Thus, noxious algae and undesirable aquatic weeds may become more predominant. Finally, Lakes Dora and Beauclair presently have poorer water quality than Lake Apopka for many parameters. Therefore, the complete shut off of input water from Apopka is an ill-advised and environmentally unacceptable management scheme for these lakes.

18. Response to N. Rex Clonts, President of Clonts Farms, Inc.: As described in Appendix B of this report, the irrigation plan for the muck farms has been altered significantly. The original plan called for restoring sections of the Willows Dike so that water could be channeled between it and the Farmers Dike to provide irrigation. As stated in your letter, "There is no Willows Dike" or at least there is little possibility of restoring the Willows Dike to a usable form. In addition, the poor soil conditions in the area have caused much concern on the part of the engineers (see Section 4 for more details). Since the overwhelming problems of the original plan have led to a new irrigation scheme, there is no possibility of rebuilding the Willows Dike to 20.7 m (68 ft) msl. Instead, irrigation water will be routed through existing interior canals, and plans call for emergency preparedness to handle any leaks in the Farmer's Dike.

As explained under Engineering Concerns in Section 4, RSB&W is quite aware of the problems involved when the existing dikes are exposed. The revised engineering design strongly recommends further geotechnical work and stockpiling of adequate materials and equipment velocities will not erode the Dora Canal because any velocities less than 45.7 m/min (2.5 ft/sec) are considered nonerodible for channels carrying colloidal silts.

Therefore, if these velocities will not erode the canals where velocity is greatest, there is even less chance of your property being eroded. Although your concern is understandable, the design velocities are quite appropriate. In addition, the contractor selected for the project will be required to place rip-rap where necessary to prevent scouring and sediment transport during the drawdown.

Closing the Apopka-Beauclair Canal would not be an acceptable water management scheme for the Oklawaha Chain of Lakes. Outflow from Lake Apopka averages 83.9 million $m^3$/year (94 $ft^3$/sec). This is an important part of the water budget to downstream lakes. If Lake Apopka were blocked off, the entire hydroperiod of the chain of lakes would be significantly altered, which could cause extreme environmental damage. Levels of downstream lakes would decrease, the diluting effect of the normal flow would be negated and water quality of the downstream lakes would actually become poorer.

Lake Apopka would also suffer from such action. The net input to the lake varies considerably throughout the year (page 31, DEIS). If outflow through the Apopka-Beauclair Canal were restricted, water levels would rise, causing local flooding. Eventually, water would begin to sheet flow through Double Run Swamp to Lake Harris as it did before the Apopka-Beauclair Canal was constructed. This would degrade the water quality in Lake Harris and adjoining lakes, thus compounding the problem. Also, allowing no outlet through the Apopka-Beauclair Canal may increase the detention time of Lake Apopka, which could lead to an increase in nutrient levels, more algal blooms and increasing rates of organic sediment accumulation. This would minimize the potential success of any further lake restoration programs and is strongly discouraged.

to handle potential dike problems. Prior to the drawdown, soil borings and geotechnical analyses will be conducted on all affected dikes, and improvements will be made to sections of the dikes which are structurally inadequate to safely handle the drawdown. During the entire project, a geotechnical engineer will constantly monitor the dikes and note any changes or damages which must be repaired. Equipment and materials will be used as necessary to maintain the integrity of these dikes to the maximum extent possible. This equipment will remain on site for an appropriate period following refill, since sheer forces on the dikes will be greatest when the lake level reaches its normal elevations.

This project has numerous problems and inherent risks due to its magnitude and the number of individuals affected by the fluctuating lake levels. The importance of maintaining the dikes and meeting the drawdown/refill schedule is recognized by the consulting engineers. All necessary actions will be taken to accomplish those objectives. Under the proposed project design, the possibility of losing irrigation water during the Spring is low since this period coincides with the drawdown phase when it is advantageous for the farmers to use water which will have to be drained from the lake anyway. During the Fall, which is the refill period of the project, the dikes will be most subject to structural damage; hence, the appropriate precautions are being taken by RSB&W in their final design.

19. Responses to Neil R. Greenwood of Bromwell Engineering and Al Stewart:
Although the proposals outlined in your respective letters appear at first examination to be acceptable alternatives to the RSB&W design, further analyses reveal many problems. These problems are inherent in any design to restore Lake Apopka and must be satisfactorily addressed to ensure the success of the project. A review of the Greenwood and Stewart proposals by DER staff and comments specifically explaining associated problems are contained in Appendix C of this report. The reader is encouraged to refer to that section for more complete responses to the related proposals.

20. Response to Raymer Maguire:

The first comment, concerning contributions of nutrients to Lake Apopka from fish kills, incorrectly paraphrases the DEIS. It was not just one fish kill that contributed more pollutants than the Winter Garden Sewage Treatment Plant; it was all fish kills and hyacinth sprayings. Page 6 of the DEIS states, "FG&FWFC personnel estimate that the nitrogen and phosphorus available in deliberately killed shad and hyacinths exceeded by 1.5 times the total nitrogen and phosphorus added by the Winter Garden Sewage Treatment Plant during the past 37 years."

Concerning the removal of rough fish prior to drawdown, the DEIS recommends harvesting but would develop a plan for such action only if and when the proposed drawdown is funded. Any fish removal plan would have to be closely coordinated with the Florida Game & Freshwater Fish Commission. It should be noted, however, that fish harvesting is not a very effective means of removing nutrients from the lake. (See response to FG&FWFC in this section for more details).

The DEIS favors the harvesting of terrestrial vegetation which would grow on the lake's exposed bottom, but also explains the difficulties involved in such action (pages 140-142 DEIS). The cost of weed removal, logistical problems of working on the newly consolidated bottom, and the difficulty of finding adequate disposal sites make the harvesting of terrestrial vegetation infeasible. Therefore, it is not included in the proposed budget. Page 142 of the DEIS contains an informative discussion of the advantages and disadvantages of vegetation removal.

A percentage chance of success for the proposed drawdown is not given during the EIS process because it would be extremely difficult to quantify such probabilities. Many benefits and results of drawdown have been documented through analyses of previous natural and man-induced drawdowns, but lake restoration, especially by drawdown, is still in its preliminary stages. Therefore, some of the effects of this restoration technique can only be identified through scientific conjecture. As Section 4 of this document explains, many of the expected results of drawdown can only be specifically quantified through further studies or through the implementation of a scaled down version of the proposed project.

The overall success potential of the Lake Apopka drawdown depends upon many factors, including the degree of muck consolidation, the extent of terrestrial vegetation growth, favorable weather conditions and construction schedules, and numerous other associated factors. Thus, it would be misleading and inappropriate to calculate a probability of success figure at this time. When and if other studies are completed or a test drawdown is funded, an estimated guarantee of success may become more feasible.

Further explanation of why the DEIS stated there should be no significant adverse effects to citrus groves is contained in the Bartholic and Bill (1977) study (Appendix D, DEIS). In their investigations, Drs. Bartholic and Bill analyzed data on the following subjects:

1. Minimum temperature of freeze episodes and approximate duration;
2. Seasonal accumulation of hours at temperatures of -3 degrees C (26 degrees F);
3. Wind speed, direction, and duration for freeze periods occurring over a 20 year period;
4. Air temperature minimums for all nights and for all cold nights (less than 2 degrees C); and
5. Probabilities for air temperature being lower than a certain temperature range (-9 to 0 degrees C) at least once in any season for several stations in the Lake Apopka region.

The model developed by Bartholic and Bill using the above mentioned data showed that at 19.5 m (64.0 ft) msl, air and water surface temperatures decreased only 0.5 degrees C from temperatures expected with the lake at normal levels.

The surface area of Lake Apopka at 19.5 m msl is 98% of that at normal levels; consequently, land surface area protected by the lake's warming effect should remain basically the same. Furthermore, the lake will be maintained at 19.5 m msl by pumping facilities, which should give citrus growers further insurance against the natural fluctuations in lake levels that have occurred during the past winters.

The work done by Dr. Clark (1976) was studied by Bartholic and Bill and is referenced in their report contained in the DEIS. It should be noted also that Clark did not address the effects of partial drawdown conditions to 19.5m (64.0 ft) msl. His report analyzes the effects of the drawdown as it was originally envisioned in 1976. At that time, plans called for draining and refilling the lake over an 18 to 30 month period, with refill occurring by natural means. Therefore, Clark (1976) assumed that during the critical winter period, "...thousands of acres of bare lake bottom would be exposed." Although this assumption was correct in 1976, the drawdown schedule has been subsequently altered so that Lake Apopka will be at 19.5 m msl during the winter months.

It is acknowledged that the citrus growers still do not agree that a 19.5 m msl lake level for two winters will afford them the warming effect of the lake. Drs. Bartholic and Bill have estimated that further in-depth research during the winter months, as requested by the citrus growers, would cost approximately $50,000. After careful consideration, EPA and DER staff (including meteorologists, hydrologists, and atmospheric specialists) concluded that further investigations would not be likely to produce additional pertinent information on frost/freeze protection. It is accepted that Lake Apopka has a beneficial warming effect on the groves south and southeast of the lake. However, a drawdown to 19.5 m msl, exposing only 2% of the lake bottom, is not expected to significantly reduce this effect.

# SECTION 8

# TRANSCRIPT OF PUBLIC HEARING ON DRAFT EIS AND RESPONSES TO COMMENTS AND QUESTIONS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IV

- - - - - - - - - - - - - - - - - - - - - x
A Public Hearing in the Matter of:

LAKE APOPKA RESTORATION PROJECT
LAKE AND ORANGE COUNTIES
TAVARES, FLORIDA
- - - - - - - - - - - - - - - - - - - - - x

Date: April 10, 1979

Time: 7:30 p.m.

Location: Agriculture Center Auditorium
State Road 19 South
Tavares, Florida

-oOo-

BAY PARK REPORTING COMPANY
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THE PANEL:

ALEC LITTLE
Deputy Regional Administrator
EPA, Region IV

JIM JOWETT
Clean Lakes Program Staff
EPA, Headquarters

GENE RAYBUCK
Project Officer
EPA, Region IV

JEAN TOLMAN, ADMINISTRATOR
Water Resources and Preservation
State of Florida

ROBERT HOWARD
EPA, Region IV

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| **SPEAKERS** | **PAGE** |
|---|---|
| Charles F. Beaver | 35 |
| Neil R. Greenwood | 36 |
| David Crepps | 38 |
| Herbert H. Zebuth | 40 |
| Edward W. Scheer | 45 |
| Kenneth C. Sedlak | 46 |
| C.E. Heppberger | 48 |
| Raymond F. Maguire | 50 |
| R.W. Sherman | 61 |

FORM RR-125 REPORTERS PAPER & MFG CO 800-626-6313

# PROCEEDINGS

(Whereupon, at 7:35 p.m. the hearing was called to order)

MR. LITTLE:

I'd like to call the meeting to order and welcome each of you tonight to the public hearing that we're having on the Draft Environmental Impact Statement for the Lake Apopka Restoration Project.

I'm Alec Little, Deptuy Regional Administrator, EPA, Region IV, in Atlanta, Georgia, and I've been designated by the Regional Administrator, Mr. John C. White, to chair the hearing tonight.

I have a statement of a few minutes' duration that will help outline the procedure that we'll be using, introduce to you some of the people up here at the front, if you'll bear with me for a few minutes; then we'll get right to the purpose of the hearing, and that is to hear from you.

The National Environmental Policy Act of 1969 requires an agency of the federal government to prepare an Environmental Impact Statement whenever that agency proposes to take a federal action significantly affecting the quality of the human environment.

The Lake Apopka Restoration Project's Environmental Impact Statement is a joint effort of the Florida

Department of Environmental Regulations and the U.S. Environmental Protection Agency, EPA.

This project is the culmination of the efforts for more than a decade of many individuals and organizations. Since the restoration of Lake Apopka constitutes a major federal action significantly affecting the quality of the human environment, an Environmental Impact Statement has been prepared.

The federal government is involved in this "major federal action" in two ways. The EPA is considering partially funding the restoration under the provision of the Clean Lakes Section of the Clean Water Act. Various permits will also be required from the Corps of Engineers before the required construction can be accomplished. By mutual agreement, EPA is functioning as the lead agency in preparing the EIS.

The EPA, responding to the mandate of the National Environmental Policy Act, issued a notice of intent on February 24, 1978, to prepare an Environmental Impact Statement. This public hearing is being held pursuant to the guidelines of the Council of Environmental Quality and the regulations of the Environmental Protection Agency with regard to the preparation of Environmental Impact Statements.

The purpose of the public hearing is to receive comments from the public on the draft EIS. This draft is being discussed in a public forum to:

1) Encourage full participation of the public in the EPA decision making process,
2) To develop greater responsiveness of governmental action to the public's concerns and priorities and,
3) To develop improved public understanding of federally funded projects.

An official report of these proceedings is being made and will become a part of the record. Notice of the public hearing was published in the Lake Region, Lake County Citizens, Sentinel Star and the Leesburg newspapers, March 28 and April 4.

At this time I'd like to introduce the other persons that are on the panel here with me. Ms. Jean Tolman ---

A VOICE:

Would you turn that up a little, please?

MR. LITTLE:

I don't have the control.

A VOICE:

I thought you had a mike there.

MR. LITTLE:

I have a mike, but I don't have the controls. Let's try this. Is that a little better?

A VOICE:

Better, a little better, yeah.

MR. LITTLE:

Okay. You wave your hand in the back now if you can't hear, and we'll try to adjust as best we can.

A VOICE:

Thank you.

MR. LITTLE:

Okay. Again, Ms. Jean Tolman, the administrator of the Water Resources Restoration and Preservation of the State of Florida Department of Environmental Regulations, on my right. Mr. Tom Furman, Vice President, Department of Environmental Regulations' consulting engineering firm of Ross, Saarinen Bolton and Wilder. That's pretty good for an amateur.

On my left, far left, is Mr. Jim Jowett of the Clean Lakes Program in Washington of EPA. Mr. Bob Howard on my left, who is chief of our EIS Preparation group in Atlanta, and that constitutes those that are up here.

You'll hear from some of these people as we go on, and at this time I would like for Mr. Jim Jowett to speak on the Clean Lakes Program, that program that brought us here together, the funding part of what we're talking about here at Lake Apopka. Mr. Jim Jowett.

MR. JOWETT:

Thank you. Well, I certainly appreciate the time everybody's taken to come out tonight, and the Clean Lakes Program is very interested in all of your comments.

The Clean Lakes Program is authorized ---

MR. LITTLE:

Speak up, Jim.

MR. JOWETT:

I'm sorry. The Clean Lakes Program is authorized under Section 314 of the Clean Water Act. The program provides financial and technical assistance to states to restore and protect their publicly owned fresh-water lakes

Lake restoration projects are funded on a 50 percent matching basis. The first lake restoration project was funded in 1975, and since this time the program has funded 94 lake restoration projects in 33 states at a total federal cost of $34 million.

The program currently has $11 and a half million in uncommitted funds.

Lake Apopka is the largest lake the Clean Lakes Program is involved with. The science of lake restoration is very new, and we have no other projects at this time which involve drawdown and sediment consolidation on a

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lake of this size.

Significant progress has already been made towards controlling pollution sources in the surrounding water shed, and EPA is very interested in complimenting this effort by implementing a lake restoration project in Lake Apopka.

Thank you.

MR. LITTLE:

Thank you, Mr. Jowett.

I'd like now for Mr. Gene Raybuck of our EIS Preparation section in Atlanta to speak on EPA's involvement with the National Environmental Policy Act.

MR. RAYBUCK:

Thank you, Mr. Little. Good evening.

First of all, I would like to thank Ms. Jean Tolman and her staff for the work that they have done in assisting EPA in preparing this draft EIS. I would also like to thank Ms. Suzanne Walker, field Project Officer -- Ms. Walker's also with the DER -- for coordinating the Citizen Review Committee meetings.

I also wish to thank the Citizen Review Committee for their time and their effort and their input in the preparation of this draft Environmental Impact Statement.

I'm going to reiterate here a little bit here what Mr. Little just said. As Project Officer, I'm

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responsible for assuring that EPA meets its obligation under the National Environmental Policy Act. This is known as NEPA. NEPA requires all agencies of the federal government to prepare detailed statements on major environmental impacts, proposals for legislation, and major federal actions significantly affecting the quality of the human environment.

Further, NEPA requires that agencies include, in their decision-making process, an appropriate and careful consideration of all aspects of a proposed action. In order to meet these requirements, EPA has prepared the draft Apopka restoration EIS. As Mr. Little has said, the major federal actions considered in this EIS is the issuance of funds for 50 percent of the project costs by EPA in obtaining the necessary permits from the Corps of Engineers.

The EIS is broken down into four major sections. The first section is the existing environmental conditions within the study area. It covers meteorology, climatology, topography, geology, soils, hydrology, water quality, biology, air quality, land use, population projections and characteristics, and economic forecasts.

The second section addresses the alternatives and their effects. The alternatives considered here were no action, enhanced fluctuation, chemical sedimentation,

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dredging, nutrient diversion, flushing, aeration, drawdown and sediment consolidation. The third section gives a description of the selected alternatives. The selected alternative in this draft EIS being considered by EPA is drawdown.

The last major section addresses the impacts of the proposed alternative and mitigative steps for identifying adverse impacts.

This section covers water quality impacts and mitigative steps, bioligical impacts and mitigative steps, meterological impacts and mitigative steps, and also impacts of increased Lake Beauclair sedimentation and subsequent drawdown. Following the hearing, at the closing of the comment period, the Environmental Protectio Agency, along with the State of Florida, will respond to all written and oral comments. The responses will be included in the final EIS. The written comments should be sent to Mr. John E. Hagan, III, Chief, EIS Branch, EPA, Region IV, 345 Courtland Street Northeast, Atlanta, Georgia. The zip code is 30308. This address is given in your agenda for the evening's program. Thank you for coming and thank you, Mr. Little.

MR. LITTLE:

Thank you, Gene. At this point, I'd like to ask Jean Tolman to present the State of Florida's role in this project.

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MS. TOLMAN:

I would also like to thank you for coming this evening. I see a lot of familiar faces here, and I think that my staff and I have become pretty well acquainted with a number of you over the last year.

I'll try to make my remarks very brief, because we've covered a lot of this ground before.

As you probably know, the Lake Apopka Restoration Project goes back a number of years with the State. It was initially a project of the Department of Environmental Pollution -- pardon me -- Department of Pollution Control for the state of Florida. Then subsequently the Game and Freshwater Fish Commission took over the project, and they received a Clean Lakes grant in 1976, and shortly thereafter, in 1976, the legislature assigned this project to the Department of Environmental Regulation.

So our involvement with it starts in July of 1976, and at that time the Clean Lakes program grant was transferred to our department.

As Mr. Jowett explains, we receive 50 percent federal funding for continuation of the project from the Clean Lakes program.

We began in 1976 some studies. Although quite a bit of work had been done on investigating the problem, we felt there were some gaps existing in information, and we began some studies, including the frost/freeze study that many of you are familiar with in this audience.

And in December of 1977, we entered into an agreement with the firm of Ross, Saarinen, Bolton and Wilder to do engineer and environmental studies for the proposed lake drawdown.

Although the earlier agencies had concluded that a drawdown was the restoration method of choice, the engineering work, the actual studies to perform such a project had never been performed, so this work was begun under contract in December of 1977.

Shortly thereafter, we felt that the magnitude and the potential controversial nature of the project required the entire question of what should be done to restore Lake Apopka, what techniques should be used, that entire question should be revisited, and we mutually agreed with EPA in the spring of 1978 that an Environmental Impact Statement was called for, and so some of you may recall we had our first public meeting in March of 1978, just over a year ago.

The EIS process was begun at that time with the department providing technical assistance to the Environmental Protection Agency for performance of the writing of the draft, so you can probably see, our involvement with EPA in this process has been on two fronts. Two totally separate parts of the Environmental Protection Agency have been involved, the Clean Lakes program funding the project, and the EIS branch participating with us in the writing of the Environmental Impact Statement.

The reason we're here tonight is that the Draft Environmental Impact Statement did reach the conclusion that the drawdown restoration method was the method of choice for the restoration of Apopka, and we do have with us tonight our consulting engineers to describe the project, which is also described as the recommended alternative in the Environmental Impact Statement.

Thank you very much.

MR. LITTLE:

We'll now turn to Tom Furman to present the project for his firm as consulting engineer to the Florida DER.

MR. FURMAN:

Thank you very much, Mr. Little. I've got some slides, which I would like to show you tonight. I find it very difficult to walk and chew gum at the same time, so I'm --- It's difficult.

Fred, we'll need the lights off. Thank you very much.

(Slide)

My purpose in the program is simply to run over the project, so if you'll like to ask questions later on, at least you'll know what has been proposed and have kind of a quick background of what the overall project is.

As Jean Tolman said, we started in December of 1977 working on the project ---

A VOICE:

Can't hear you.

MR. FURMAN:

Can you hear me now?

A VOICE:

Better.

MR. FURMAN:

Okay. You might have to come up here if you're having a little difficulty.

A VOICE:

Talk into the mike.

MR. FURMAN:

Thank you. Harassment already.

The purpose of the project was, of course, to take Lake Apopka, which is highly eutrophic right now and restore it as best we can, something that will resemble this.

(Slide)

Lake Apopka is a lake some 31,000 acres. You all know where it is, so I won't go through this.

(Slide)

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The preceding studies that have been conducted by DER are listed here. They consist mainly of the frost/freeze study, a hydrological study conducted by the U.S. Geological Survey, a data update, a legal study, and various limnological investigations. Once those were all conducted, the State decided to proceed with all haste in getting the engineering design done, and that was our part.

(Slide)

Basically what we're talking about is drawing down Lake Apopka in a three month period starting in March, holding it down for two months, and then filling the lake by the end of November, and this series of slides right here shows you what we're talking about when we're referring to the Lake Apopka Restoration Project.

It would begin in September, and the lake might, let's say, would be at 66.5, 67 feet, whatever it is, and then by gravity --

(Slide)

-- would be drawn down to 64 feet mean sea level on February 1st. Now, during all this time, there would be significant construction taking place, constructing the coffer dams and all the other facilities that we will be describing later.

At 64 feet mean sea level, the gravity drawdown

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would stop.

(Slide)

On March 1st the pumped drawdown would begin, and we would start pumping at the rate of about 500 million gallons a day for three months. On March 1, the lake would look something like that, elevation 64 feet, practically no bottom exposed, and the lake would be about 3 feet lower than it normally is. Okay.

On April 11th, the elevation would be 62.5 feet, and the bottom shown here in brown, that's how much bottom would be exposed.

(Slide)

On May 2nd, it would be at an elevation of 61.5 feet, and that much bottom would be exposed.

(Slide)

On May 17th, she would be down to 60.5 feet.

(Slide)

On May 27th, at 59.5 --

(Slide)

-- and on June 1st, if everything holds, as we predicted, we would reach an elevation of 58, and that's where we would stop drawing down the lake any further. It doesn't mean we'd stop pumping. We just would not draw the lake down any more than that, and that would be about how much bottom. Some of those little pockets of water you see may

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or may not remain, but that's probably a pretty good idea of what the bottom of the lake would look like.

Now, you're talking about roughly 49 square miles of lake bottom, so that's a tremendous amount of land area exposed right there.

Okay. June 1, we start what we call the holddown, and what we're trying to do during this period is simply pump the water out of the lake fast enough so that we can maintain that elevation of 58 feet. We will hold it down at that elevation for two months --

(Slide)

-- all of June and all of July.

(Slide)

Okay. On August 1st, we would start refilling the lake, and we call that the refill period. Okay. We've got four months to get it filled up before December 1st.

(Slide)

And so August 8th, the lake would be back at 59.5 --

(Slide)

-- August 20th, 60.5 --

(Slide)

-- September 8th, 61.5 --

(Slide)

-- October 6th, 62.5 --

(Slide)

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-- and November 30th, it would be at 64 feet mean sea level. Now, the reason we talk about starting on March 1 and ending on November 30th, that's a nine month period, is so that we will have water in the lake during the preceding drawdown year, the year preceding the drawdown, so that the citrus farmers or the citrus groves on the south side of the lake will have some type of thermal protection from the cold winds that blow during the winter months.

When we get it back to 64 feet mean sea level on November the 30th, we will again have provided them with what DER feels like is adequate thermal protection. That's the reason the project is designed to begin and pretty much end within nine months.

(Slide)

The big question is will the muck consolidate. We conducted a study. It was done by Dr. Schmertmann and Dr. David Crepp --

(Slide)

-- to determine whether it would consolidate, because if it does not, from our standpoint, the project, of course, would be a failure.

A significant amount of geotechnical work was done in the lake.

(Slide)

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Maps were prepared indicating the amount of muck and the way it would be, and it was judged firm enough not to flow during the drawdown. Muck samples were taken and tested to determine would the muck consolidate and would it re-suspend upon refill.

(Slide)

And various maps were drawn.

(Slide)

This one shows right here the areas of the lake that we think that would be significant consolidation, no consolidation, etcetera. And based upon their study, they concluded, or it was their opinion, that drawdown would be most beneficial in getting the most of the muck bottom to consolidate. Okay.

(Slide)

Once that was done, we then looked at the hydrologic and hydrological aspects of the project. We wanted to find out could we store enough water in the downstream lakes so that we could fill Lake Apopka back up within a four month period.

(Slide)

We developed a probability analysis of the rainfall--

(Slide)

-- and concluded, during the drawdown and holddown periods, we would be most concerned about rain. If it was a very,

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very wet year, then we would have a lot more water to pump than we would normally have, but we found out that no matter how hard it rains, we could install enough pumps and design them into our project to remove all the water that could possibly fall during the drawdown and holddown periods.

(Slide)

Now, when we start to fill the lake back up, we want it to be wet, because we need a lot of water, so we looked at the worst possible condition again, and that is what if we have an incredibly dry year, and we found that it was about a 97 percent chance that any rain that we have -- about a 2.5 percent probability that we won't have enough rain to refill the lake without having to drop some of the downstream lakes a little bit below their regulatory level, so for all practical -- from a practical standpoint, there is enough water in the downstream lakes to be able to fill Lake Apopka back up.

(Slide)

Okay. We developed a lake regulation schedule, which I won't explain here; it's pretty complicated. It just shows the condition or the elevation of every lake during every month of the drawdown period.

(Slide)

Then we looked at sediment and nutrients to determin

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could we get the sediment, the muck, out of Lake Apopka --

(Slide)

-- and keep it from going downstream. We did an incredible amount of field work.

(Slide)

We looked at the stratification of the lake. We did all kinds of jar tests to determine what would be the best settling characteristics and facilities to remove the muck.

(Slide)

And we finally concluded, even though it was very tough to design a sedimentation basin for a 500 million gallon per day flow that an in-lake sedimentation basin would be the thing to construct, and we thought that it would remove enough of the muck so that we could meet the water quality standards downstream. Okay.

(Slide)

We also realized that we could not capture all the muck that might leave the lake, and what we did not capture would probably end up in Lake Beauclair. After a little bit of investigation, we realized, for not a great deal of money, we could also restore Lake Beauclair, and any muck that got out and was captured in that lake could be taken care of during the restoration of that lake at the conclusion of the Lake Apopka Restoration Project.

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(Slide)

Okay. We looked at the ecological impacts --

(Slide)

-- and both the impacts of the canals, what would be the impact of moving huge quantities of water down some very narrow canals --

(Slide)

-- what would it do to some of the sensitive areas downstream, like the Dora Canal, and of course in the various lakes, and we concluded there that though there would be short-term environmental impacts, some kind of adverse, that nothing's so significant to stop the project could be anticipated, and consequently we proceeded on.

(Slide)

We then began to design facilities to accomplish the total Lake Apopka Restoration Project, and I'll run through this real quickly.

(Slide)

The first thing that we needed to construct would be what we call a depot channel in the lake to connect all of these little low spots, so that when we pull the lake down, the lake will drain as a unit. This is a channel some 14,300 feet long.

(Slide)

Its cross section is shown here. We'd have a

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bottom elevation of about 48 feet, and it's designed to have a velocity of about one half a foot per second, very, very slow, because we're hoping we can settle out most of the muck in that channel prior to getting to the basin.

(Slide)

Next the basin is shown here, and this is a very, very large facility. I believe it's about 1,000 feet by 4,300 feet, a hold in the lake where the water would receive quiescent settling, and most of the muck would settle out.

(Slide)

At that point, at the south end of the Apopka/ Beauclair Canal, which I'll refer to as ABC from now on, we will construct a pumping station with about ten --

(Slide)

-- pumps, which will move water at the rate of about 500 million gallons a day over a coffer dam constructed of sheet pile filled with sand, and the water would then flow downstream or kind of north up the ABC into Beauclair.

(Slide)

The pumps that we would use are shown up here. They would be double stage pumps driven by a 460 horsepower diesel engine.

(Slide)

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We took a long and hard look at the ABC. We did some soil work to determine are the dikes high enough, will they stand up under this kind of loading, and is there silt and muck in these canals, which must be removed prior to starting the project.

We found there were places that there was quite a bit of muck, and this would have to be removed. Otherwise, it would be washed in the downstream lakes, and we don't want that to occur.

(Slide)

When we get to the Dora Canal, we have a very interesting problem, because we need to move about twice as much water through the canal as the canal can handle, so we were faced with a dilemma, and that is how to move out about 200 million gallons a day of water around the Dora Canal.

(Slide)

We proposed a pumping station, which is shown here, on the south end of the Dora Canal. It will have seven pumps, each pumping at the rate of about 300 -- I beg your pardon -- 30,000 gallons per minute.

Each one will be driven by two 200 horsepower electric engines. We selected electric motors -- I beg your pardon -- electric motors to keep the noise as low as possible in that area.

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We've got to pump that water into something, and we are talking about an 84-inch diameter steel pipe. It will make an above-the-water crossing of the Dora Canal and then run pretty much through the City of Tavares, along the railroad right of way, all the way down to Lake Eustis.

Now, this pipe is 84 inches in diameter; that's a big pipe. It will be steel. It's 7 and 7/16 inch thick with welded joints and will be about half buried and half not buried.

Most of it will be directly in the railroad right of way. We'd remove some of the abandoned tracks and put the pipe right there, because it provides excellent bedding.

(Slide)

Of course, if you live in this area, you know how devastating it would be to have the water of Lake Apopka back up into Lake Harris and Little Lake Harris.

We plan to take care of that problem by constructing a dam across the Dead River, right about where that arrow is.

(Slide)

The dam will look something like this. It will prevent water from backing up, and also it will be a water control structure, so that as we start refilling

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the lake, we can get water from Lake Harris to flow over the weir, which is shown by the red lines there.

Of course, you want to maintain boat traffic during this time, so we're proposing two facilities; one will be a fork, you know, a travel -- I beg your pardon -- a forklift with the marine devices that can pick up those very quickly and maneuver them around and drop them from one lake to the other, and also a very large travel lift, which can pick up the occasional gigantic boats that come through the lake.

Now, these facilities will all be in operation from March all the way through the end of June. When we get into the refill period, we'll have to pump the lake back full of water, so the pumps that were down on the south end of the Dora Canal would be moved to the north end of the Dora Canal and installed in a pumping station up there, which will look very similar to the one at the south end of the Dora Canal.

(Slide)

The water will be back-pumped through that pipeline and empty into Lake Dora. From there it will flow around to Lake Beauclair. We will construct another pumping station at the mouth of the ABC, putting in five pumps.

The pumping station that was at the south end of

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the ABC will be broken up into two parts; half the pumps placed right there where that arrow is and will be pumping at the rate of about 300 billion gallons a day over a cofferdam into the ABC canal.

(Slide)

Okay. We'll have to lift the water twice. When we get to the Apopka/Beauclair Canal lock and dam, we will construct another cofferdam across that channel, put in the additional five pumps and pick the water up again and put it in the canal and have it run due south, all the way into Lake Apopka and fill it back up.

(Slide)

Now, on November 30th of the drawdown year, Lake Apopka will theoretically be full. We will wait until March of the next year to begin the restoration of Lake Beauclair. It will be very simple. We will construct, shown by the orange tape up here, two little sheetpile cofferdams across the entrance between Lake Dora and Lake Beauclair and between Lake Carlton and Lake Beauclair, and then using the pumps that still remain, shown by the yellow piece of tape there, we can pump Lake Beauclair down. It'll only take about fifteen days of pumping, let it remain down for about two months during which time the sun, we believe, will

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consolidate the material, which is on the bottom of Lake Beauclair, and then after a two-month holddown period, we will allow the lake to fill back up, remove the cofferdams, and that will complete the project.

(Slide)

The organic soil farms use water. As you know, the farms are below the level of the lake --

(Slide)

-- and we had to look into the possibility of providing them water during the entire project.

We looked at the Willow Dike. We looked at many possible alternatives, and after a great deal of fluctuation back and forth, we finally concluded that probably the safest way to handle the problem would be --

(Slide)

-- to enlarge the Farmers Dike Canal system along the East-West McDonald Canal and the North-South McDonald Canal, as you see there kind of as the blue tape.

This is a very complex problem, because as the lake drops, the amount of water which seeps into the muck farms will be reduced, and we've got to provide them with enough water to maintain their operations as if the lake was full.

(Slide)

Citrus groves to the south end of the lake --

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(Slide)

-- also have a problem. They need the lake for water supply. A lot of them pump directly from the lake, as you see here.

(Slide)

Some of the other citrus farms, shown by this aerial photograph, use no water at all from the lake. In fact, they don't irrigate at all. The rest of the citrus groves irrigate from the Florida Aquifer or from deep wells.

Okay. We plotted, shown by the purple line, the approximate elevation --

(Slide)

-- of the water surface in Lake Apopka as we draw the lake down, and we believe that the ground water table, very close to the lake shore, will pretty much reflect what the level of the lake is.

Now, it's very difficult to determine, but after scratching our heads and putting in some monitoring wells, it was our conclusion that the area of citrus groves, approximately 1,000 feet back of the lake, may be impacted by the restoration project and consequently we would have to make provisions to provide them with water during the drawdown project.

It will probably be worse during April and May when, of course, that's the dry season here in this part of the state, the citrus trees are apparently deciding how much fruit they want to bear that year, so it's not a good time not to have water to provide them.

(Slide)

So after looking at many systems, we figured that probably the most flexible system was to use a high-rise travel or a rain gun or something like this that could be quite mobile.

We would have to construct about 29 water supply wells to provide all of the citrus groves with water even those groves that are not currently irrigated.

(Slide)

And this, of course, was quite a problem. Total cost of the project, when we did our preliminary engineering report, we estimated the net cost, or, the total cost of the project would be about $16 million or about $15 and a half million with about a million and a half of salvage, ending up with a net cost to the State of about $14 million, and that was for a drawdown in 1980.

After doing the final design and doing an awful lot more soil exploration work, we have realized that because of the incredibly bad soils that we have in the area forcing us to go over to the steel pipe, forcing us to go to heavier sections of sheetpile, forcing us to take extra precautions on the Farmers Dike to keep it from failing, because you can imagine the devastation that would occur if we lost the Farmers Dike after refilling the lake, the total cost now, we're estimating, is going to be in the neighborhood of about $22.1 million.

And we're talking about a drawdown, now, in 1981, not 1980, as we originally talked about.

The salvage value, though, was increased, and we're looking at a net cost to the State of approximately $19.8 million.

As you know, that's an awful lot of money, but then this is an awful lot of project.

(Slide)

Again, what, of course, the State is trying to do is to restore a body of water which is almost 50 square miles, is used by citrus groves, it's used by the muck farmers, it's used by the people for recreational purposes, as well as all of the downstream lakes, so it's a very, very enormous project, and we're trying to restore it from something that looks like that --

(Slide)

-- to something that is much more attractive and can

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be used for recreation.

That concludes my remarks. I hope that I --- I know it's an awful lot to throw at you, but I tried to do the best I could with twenty minutes.

Thank you.

MR. LITTLE:

Thank you, Tom. I think that was a good job of explaining in a short period of time what is a complex project.

At this point I'd like to describe the procedures for you for receiving public comment. Everyone who is registered to speak will be given an opportunity to be heard.

At this point in time we have approximately ten people who have registered. I will call for the speakers in the order of registration. I'm going to ask you to limit your remarks to ten minutes.

You may have additional time after everyone desiring to speak has had an opportunity to be heard, and we'll work it like this, that at the end of eight minutes, if you're still talking, I'll ask Gene Raybuck to stand up in the front, and you'll have a signal you got two minutes left, and at the end of ten minutes, we have some bouncers in the back that will forcefully remove you from the building but no, (Laughter), not really.

We have plenty of time, I think, for your comments this evening, so we will use that signal. When you see Mr. Raybuck stand up, you'll know you've got about two minutes left.

Another procedure that we use, we're trying to hear from you and what you think about the project. We ask that questions not be directed to the panel unless perhaps there's some aspect of the project that you would like to have described to you in a little more detail, and for that purpose, Tom Furman and some of his associates are here to help answer those kinds of questions that are clarification type.

We reserve the right to ask you to limit your remarks to relevant issues. I'd like to ask you to submit your statements in writing. That's a great help to us, but if you don't have them, we are taking a record.

Formal rules of evidence will not apply here. There will be no oath of witnesses. There will be no cross-examination or direct questions to the speakers.

Again, if there's a point that needs clarifying or data submitted that needs further documentation, some of those of us on the panel may ask questions also, and I would ask members of the panel to address any question of that type directly to his speaker. There will be no questions by the audience of any persons who make

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statements.

If you wish to rebut any remark made, please register to speak again. When you're called on to speak, please present a copy of your written statement, if you have it, to the court reporter down front and another copy to me.

If you'll stand at the speaker's podium, give your name and address, and the title or group that you're representing or that you are associated with ---

I think we're ready to begin, and the first person that we had signed to speak this evening is Charles F. Beaver.

MR. BEAVER:

Good evening. My name is Charles F. Beaver. I'm the Secretary and Promotional Director of Florida Biodynamics, Incorporated, St. Augustine, Florida. The address is Route 4, Box 273, U.S. 1 South, four miles in St. Augustine. Our telephone number is (904)794-0222.

My business here was to make an announcement, and before the meeting I asked if I could make it. On April 30th at the Lake Shores Acres Restaurant at 9:30 in the morning, Monday, there will be a meeting of the citizens who wish to come. All of you are invited to hear how we are going to control some of the pollution problems in Lake County.

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Some of the runoff that is taking place in filling these lakes can be considered part of that discussion. I'm sure you'd be interested to find out that we're planning to take and use the trash, the sludge, and the waste products of the county, and develop a plant which would process these products and deliver you something that you can put on the land that'll give you the finest tasting tomatoes and celery and lettuce, whatever have you, good oranges, and so forth, that makes it available.

That's all I have to say. Thank you very much, gentlemen.

MR. LITTLE:

Thank you, Mr. Beaver.

Our next speaker is Mr. John A. Carlin.

MR. CARLIN:

Yes. I've decided I'll ---

MR. LITTLE:

Mr. Carlin, could you come down front?

MR. CARLIN:

I'll submit my comments to Mr. Hagan's office in writing. Thank you.

MR. LITTLE:

Thank you very much.

Mr. Neil R. Greenwood.

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MR. GREENWOOD:

My name is Neil R. Greenwood. I'm a consultant and a professional engineer from Lakeland, and I'm very much in favor of lake restoration, and I've reviewed this data and find it very complete and thorough, and I agree with the method that was selected -- that is, lake drawdown -- as the most effective way to do this.

But I don't really feel the project itself is cost-effective, and I know I haven't put as much time on it as some of these other people have. This is an awfully high cost, and it just went up about $6 million tonight from what I've seen.

It's very high cost for something that's only a partial degree of success. The amount of lake bottom which is going to be exposed, according to the EIS, is about 30 percent.

Another 30 percent won't be touched, and the other 40 percent is only partially exposed, meaning that the surface will be exposed, and the bottom won't.

The decrease in muck volume is only about 10 percent. The inconvenience to other lakes and canals is extensive.

I'd like to suggest that there might be another way to do this for a lot less money. This might involve putting in some dikes and doing sections of the lake, one

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section at a time, maybe quartering the lake.

These dikes could be done with dredges or drag lines. I think the cost would be somewhere in the order of $3 or 4 million.

The effectiveness of the first phase, and this way it could be proven before you commit any further funds. It won't be, as is now, with everything in one basket, and you won't have the critical schedule to meet, where you've got the citrus crops that need protection, and if you have project problems, lightning strikes, anything that happens won't louse up the project in the middle.

I have my written report here that says it a little better.

(Whereupon, a document was presented to Mr. Little)

MR. LITTLE:

Thank you, Mr. Greenwood.

I think perhaps there is one item of clarification that we might make with respect to one of your comments, and I would ask Mr. Furman to make that comment.

MR. CREPPS:

My name is David Crepps, and I'm a consultant from Gainesville. I've worked with Ross, Saarinen Bolton and Wilder on the Apopka Restoration Project. I was directly involved in the muck consolidation study, and I just

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wanted to apply it to some of the facts that he gave.

First he said there was only a 10 percent decrease in the muck. What the 10 percent figure was was actually that much increase in volume in the lake.

The other figure that he mentioned or that he said there was only 30 percent of the lake exposed, that is not true. As Mr. Furman pointed out, most all of the lake bottom is exposed.

The thing, the 30 percent figure that was referred to in the Environmental Impact Statement is that there's 30 percent of the lake bottom that will have a very definite hard crust.

There's another 30 percent that will have a lesser degree of consolidation, and then there would be a portion that will have essentially no change in characteristics.

So there are various degrees of consolidation, and all the figures that are in the Environmental Impact Statement or in their earlier report are conservative figures.

MR. LITTLE:

Thank you.

Mr. Greenwood, if you would like to rebut any of those comments that were just made, please feel free to do so at the end of the speaking period.

The next speaker is Mr. Herbert H. Zebuth. Is that

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close?

MR. ZEBUTH:

That's excellent. You surprised me.

My name is Herb Zebuth. I live in Orange City, and I'm representing myself.

A review of the above referenced draft document indicates several areas of concern that are not fully covered or adequately addressed.

One major area of concern, especially to local residents, is the effect the rapid drawdown will have on the water quality of downstream water bodies. Presently, water quality downstream improves as distance from Lake Apopka increases.

The best water quality is in Lakes Yale, Harris, and Little Lake Harris which do not receive Lake Apopka effluent, the worst in Lakes Carlton, Beauclair, and Dora, the closest to Lake Apopka. A large majority of the nutrient loading to Lake Griffin, last in the Lake Apopka chain, is received from upstream sources (pages 39,40).

This data tends to indicate two trends. First, there already is an existing export of nutrients from Lake Apopka. Secondly, the storage of a portion of those nutrients in downstream lakes is presently occurring, as evidenced by the improvement in water quality with distance from Lake Apopka.

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Most lakes appear to have a limit to quantity of nutrients that can be absorbed. Often a continuous algal bloom results when this limit is exceeded. Such a bloom may be self-sustaining due to the rapid recycling of nutrients such as now occurs in Lake Apopka. Periodic algal blooms already occur in the downstream lakes (page 39).

An important question to be answered is whether the drawdown will result in an increased nutrient load to the downstream lakes. The draft document states no nutrient load to downstream lakes --- Excuse me. The draft document states no increase in the nutrient concentration of Lake Apopka water is expected (page 137), but later states that increased nutrient concentrations could lead to algal blooms in downstream lakes (page 153). Logic would lead one to accept the latter statement.

An increase during drawdown of nutrient concentrations in Lake Apopka effluent will result from several factors. At present, wind action, which causes prolonged resuspension of bottom sediment (page 135), is the major factor releasing and recycling nutrients to sustain the continuous algal bloom (page 133).

As the water level increases during drawdown, the wind will exert an increasing force on the sediments resulting in deeper mixing and greater nutrient release.

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Secondly, the dredging which will be necessary to construct the various channels and the large sediment basin within the lake and the dredging to keep the channels and basin open will release additional nutrients (page 135

Finally, as the lake level recedes to the deeper hole, the interstitial water in the flocculent sediment will also drain to the remaining lake water. In some lakes, the interstitial sediment water has been found to contain nutrients concentrations fifty times higher than the overlying lake water. Due to the retention time of the water in downstream lakes, this additional nutrient load will alter the existing ecosystem and remain "long after drawdown" (page 137).

Terrestrial weeds are expected to invade the lake bottom during holddown (page 140). Many of the factors associated with such an invasion were adequately discussed.

One possibility which has occurred in drawdown of a lake with sediment similar to Lake Apopka was not discussed. After refill, terrestrial weeds floated to the surface, carrying with them the consolidated sediment held by the entangled root systems.

The seriousness of such an occurance would depend on several factors, such as the depth to which the sediment had consolidated and the effect of the gradual

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release of the root bound sediment on water quality and sediment consistency.

The possibility of a hydrilla invasion of Lake Apopka was discussed and ended with the statement that hydrilla performs all the biological functions of macrophytes (page 139). Although this is true, the effect of the biological functions of one species can differ greatly when compared to the effect of such funtions of a different species.

Zero dissolved oxygen levels have been recorded beneath dense hydrilla mats caused by the decomposition of dead plant material and the restriction of natural mixing. Although hydrilla can absorb large quantities of nutrients from the water as its biomass rapidly expands once space becomes limiting, these nutrients can be quickly recycled.

As a submersed species, buoyed by the water column, the plant has little need for a large quantity of cellulose for structural strength. As a result, its rapid decomposition does not allow for the trapping of nutrients in the sediment as do more fiberous emergent plants.

The most important factor involved in this project is the consolidation of Lake Apopka's sediment. Although many lake drawdowns have been accomplished in Florida, few had sediments similar to Lake Apopka, and all were helddown for a much more extended period than is currently planned.

The question of how successful the project might be in accomplishing its primary goal, sediment consolidation, was not adequately addressed or discussed. This question is of such paramount importance to the success of the project, that it deserves to be discussed in some detail in the document.

We had a section in the appendix that dealt extensively with the freeze study. I would think that the question of the experiment to determine the success of sediment consolidation would have been at least as important as the freeze study.

The failure of this project could have a substantial negative impact on future lake restoration projects in Florida.

(Applause)

(Whereupon, a document was presented to Mr. Little)

MR. LITTLE:

Thank you.

The next speaker is Mr. Bert Roper.

MR. ROPER:

I'll defer to Mr. Maguire who has since arrived.

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MR. LITTLE:

Edward W. Scheer.

MR. SCHEER:

My name is Edward W. Scheer, 301 Partridge Lane, Longwood. I'm an Associate Professor of Biology at Rollins College, and I'm representing myself.

At a prior public meeting here some months ago, I spoke to the issue that the no-action alternative did not fairly represent the spirit of NEPA. While it does the letter of the law, I submit that page 100 of the draft statement and one-third at the most of page 101 does not do justice to the no-action alternative.

A benefit of the no-action alternative would be to save, depending upon the figures, from $15 to over $20 million, and I would consider that a considerable benefit.

In Section C, toward the end of the report on, I believe it was C-21, the draft statement refused to give a cost-benefit ratio for the project. I can understand that refusal. It's difficult to spot all of the costs. It's easy to overlook many of the costs.

I think our experience in projects of the past has been to underestimate them rather systematically. I suggest that that might be the case here.

As far as the benefits are concerned, the tendency in projects of this sort, and I suspect this one, is to

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overestimate the benefits.

In terms of the fishing to be realized from a restored lake, one must realize that the people who would benefit from the restoration are otherwise employed; they have moved elsewhere. They are presumably most of them in the job market. Those who fish, many of them are fishing other places.

These are benefits that are passed more widely to the area, and if one takes the myopic view of just the confines of Lake Apopka, I think one has only a partial solution to the economics of the problem.

A restored lake would have a lag phase for the fishing to recover, a lag phase for the education to fishermen, particularly those afar, to be drawn to the area. Meanwhile, the lake declines toward a higher stage of vitrification.

Where the crossing point of these two occurs is anybody's guess, so I suggest that the supposed benefits accruing to the area by way of fishing are overestimated. Many of these benefits are now realized in the greater central Florida area accruing to other lakes around here.

I'm very leery about high engineering approaches to complex ecological problems. They tend to oversimplify the biological systems. I worry about the water quality downstream in Beauclair, for instance.

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We know ecologically that everything is connected to everything else. There is no away. The boundaries of the system clearly go beyond Lake Apopka now or during the stages of restoration or afterwards. It is not a closed system. We don't know what the limits of tolerance of downstream lakes receiving eutrophic waters would be. We don't know what the limits of those systems are and how fragile these systems might be.

Prior to Ms. Tolman coming on board, I had contact with one of the prior members of the team responsible in the State of Florida for getting together material for the draft EIS statement, and that person said in no uncertain terms that it was viewed by that prior team as a very large experiment.

I would submit to you that it is still that and a very, very expensive one at that. I oppose it. Thank you.

(Applause)

MR. LITTLE:

Thank you. The next speaker, Kenneth C. Sedlak.

MR. SEDLAK:

Well, my name's Ken Sedlak. I live in Oakland, Florida, on the shores of Lake Apopka. I have an office in Winter Park. My address is P.O. Box 98, Oakland, Florida.

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I'm like the gentleman that was here before, I live on the lake, and unlike many of you here that applaud the idea of not restoring the lake or not doing anything for it, I can't see it. I live there. It is polluted. It is in terrible shape. It has been getting worse since 1950, and we've all seen the reports and records.

All these lakes that are here trying to protect themselves about the drawdown, what's going to happen as you get closer to Lake Apopka by having the pollution of these lakes coming more closer to you? You're going to be polluted. You're going to be as bad as Lake Apopka. If you have no way --- What is the --- It's been recognized here that for a clear water lake, even the federal government would okay it and will try to help the place be restored.

You're not interested in restoring this if you're not interested for the drawdown or for some method of correcting this.

We talk about the cost. Well, I don't know if you want to leave your children or your grandchildren with a debt, or if you want to leave them with a cesspool. It's up to you.

(Applause)

MR. LITTLE:

C.E. Heppberger.

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MR. HEPPBERGER:

It's a shame to be old, but it's a pleasure to be alive.

There seems to be some different --- My name is Heppberger. I live --- I'm a taxpayer in Leesburg, and I've been President the last five years of the Lake Improvement Association. It's an input group interested in the abatement of abuses to our lakes, the whole seine of rough fish, the fluctuation of water level in the lakes and stocking them with black bass, which the State has had a big history.

But there seems to be some difference of opinion on this compaction. If this water is drawn down and the muck that is there is exposed for three months, it would make a mild cake, the best opinion I've picked up. A man that's been in the fish business in Tavares for over thirty years --- I just left him, just left his presence-- and he said that it would take a year and a half to get any kind of solid compaction, but when you flush the water back on it with the mild crust, then you have the problem of disposing of the crust as it floats downstream.

I might say this man suggested for consideration -- I'll leave it before my personal comments -- that he said don't pass the opportunity or the consideration of filling the lake up maybe one foot, two feet, maybe three feet

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more than the MSL, and then let it slush and take all that --- They spell it c-r-a-p or crud downstream. We'd have to suffer with it.

Now, as a taxpayer, I wrote a letter to the editor on a personal opinion, and we have just heard the President make a deal with two folks, that the treaty price for the U.S. is reported to be millions now and billions later. The restoration of Lake Apopka is estimated to be $15 million -- I heard it's a little more now; inflation is each day -- with no reference to cost overruns, which has been referred to. Now, how long will taxpayers, bureaucratic agencies, and legislative personnel, tolerate mortgaging future generations with projects funded by deficit spending.

Somewhere along the line we must contest the wisdom of continued deficit spending and commitments, showing a few --- they call it intestinal fortitude. There's another word you can use. People have caused the degradation of our lake water resources. People must challenge the vagaries of bureaucracy and come forward with constructive dialogue to resolve problems which will adversely affect the economic stability of our great country.

Specifically this lake has been abused for over twenty years. Continued limited flushing of nutrients into the Oklawaha chain of lakes will further impair the water

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of our area lakes.

Now, if you're going to challenge this and criticize somebody, you must also come up with something in the way of a suggestion. The writer, and others, recommend no drawdown of Lake Apopka be initiated until, one, all abuses to the lake are abated; number two, allow one year to elapse for lake stabilization; three, haul-seining the rough fish at the current water level; four, periodically fluctuate all lake levels, plus or minus one point, five feet periodically; and five, more fully explore the dredging of a reported 222 million cubic meters of much with private capital.

Now, 6 cubic feet of peat reportedly retails at $12.00. A copy of this went to Jake Varn or Mr. Varn.

Do you want it? Do you want this? You got it. It's up there now, okay?

MS. TOLMAN:

Sure. Thank you.

MR. HEPPBERGER:

Thank you very much for your attention. Let's do the right thing. Don't put our heads in the sand.

MR. LITTLE:

Thank you, Mr. Heppberger.

MR. HEPPBERGER:

Thank you.

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MR. LITTLE:

Sounds like young thoughts to me.

The next speaker, Mr. Mac Bleakley.

(No response)

MR. LITTLE:

Is he present, or did I mispronounce it?

(No response)

MR. LITTLE:

The last speaker that we have registered this evening is Raymond F. Maguire, Jr.

MR. MAGUIRE:

I'm Raymond Maguire. I'm an attorney from the law firm of Maguire, Flores and Wells in Orlando. I represent the citrus growers who have citrus groves on the south side of the lake; that is, Lake Apopka.

And I am speaking to your report and limit it to that. In our judgment, your report does not adequately address the question of what is the probability of success in establishing Lake Apopka as a Class III lake, and it's staying that way for a modest expenditure of some $20 million.

The report, as far as I can see, doesn't say it's a 100 percent chance, it's a 90 percent chance, or a 10 percent chance. We think that is an important element to contain within the report.

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If I have not been able to read the language that that is encompassed in, I'd love to be corrected, but I can't find it.

The second thing that we would like to point out to you concerning the fact that your report does not adequately address is the freeze damage.

Dr. Bartholic in a conference with the DER and myself and my weather consultants pointed out that if he were authorized to make an additional study, and I'm getting into computers, which I don't understand, he said that he could make a computer model and analyze what would happen when the lake had been half drawn down to 64 feet -- I say it's half drawn down at 64 feet -- and what that effect would have on the water being a generator of heat.

The DER has determined, as I can read your report, that that's not a very important fact. The DER apparently doesn't understand the difference between mean temperature and daily loads in the citrus belt of Florida.

In Florida, 26 or 27 degrees for two or three hours is probably very similar to what 10 degrees below for ten hours in Atlanta would be.

Atlanta, I assume, is not built for severe temperatures. Twenty-six degrees to Florida is a severe temperature in the citrus belt. It may not be in Tallahassee

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and it may not be in Jacksonville.

The report refused to consider the report that Dr. Bartholic felt was critical after he learned that the lake was to be drawn down 64 degrees by February 28th.

There is no discussion in the report of his recommendation that the temperatures in the groves be monitored. The report does not adequately address the problem of inverse condemnation by the government of the United States and the State of Florida, taking away from a property owner a God-given right, temperature, warming temperature from the lake during a freeze.

The report refers to the fact that there's some type of thermal protection at 64 feet. This goes back to the fact that the DER did not choose to perform the second Bartholic report which was estimated originally at $10,000 but would spend $175,000 on other engineering studies.

It's my understanding that the engineering studies--- The engineering firm was given a fixed, inviolate 64 feet by February 28th and a 64 feet by November 30th, and not asked to make any further investigation as to whether 64 feet was reasonable or unreasonable.

I have several technical references to your report that I will submit in written form together with a copy of the effects of lowering Lake Apopka on citrus groves,

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which was made available by Dr. Clark, an engineer and consultant, which was made available to the DER and to the consulting engineers, but is not referenced in the report.

I would like to know who was the chief author of this report, if I can be given that fact?

MR. LITTLE:

Could you show us the report?

MR. MAGUIRE:

Yes, sir.

MR. LITTLE:

We're not sure which one you're talking about.

MR. MAGUIRE:

Yes, sir.

(Whereupon, a document was presented to Mr. Little)

MR. MAGUIRE:

We submitted this to the DER about two years ago. Dr. Clark, he's a professional engineer, and we've had him involved in practically every conference with the DER for the last two and a half years.

MR. LITTLE:

I thought your question was who was the author of this report.

FORM RR-125 REPORTERS PAPER & MFG. CO. 800-626-6313

MR. MAGUIRE:

No, no. I'm asking who was the author of the --- Who is the actual author of your report, is what I'm asking. Who wrote the thing. Did y'all commission it to be done by an engineering firm, or did your own staff do it? I'd just like to know who the author is, if that's not improper to know.

MR. HOWARD:

It was a combined effort of the Environmental Protection Agency and the State of Florida Department of Environmental Regulation, and in fact a large amount of the work was, in fact, prepared by the State. It was worked --- The preparation was coordinated with the Environmental Protection Agency.

MR. MAGUIRE:

But no one person or group of persons had the writing duties? It's just a combination of everybody, is that what y'all are saying?

MR. HOWARD:

No.

MR. MAGUIRE:

I'm just curious.

MR. LITTLE:

I think the way the process worked in this particular EIS is that primarily the basis for the factual

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material and at least the draft preparation was in the hands of the Florida Department of Environmental Regulation.

This information was reviewed by EPA in Atlanta. I'm sure adjustments were made. A lot of people were involved in the writing of any of these reports; no single author.

MR. HOWARD:

There were a number of other studies, too, that were used in the preparation of this document, some of the engineering reports that had been performed, some previous studies that had been done, but basically the State of Florida Department of Environmental Regulation did the majority of the writing in cooperation with the Environmental Protection Agency.

MR. MAGUIRE:

What is the time limit on submitting additional ---

MR. LITTLE:

I'll speak to that in just a moment.

MR. MAGUIRE:

Thanks.

MR. LITTLE:

Thank you, Mr. Maguire. We have, of course, your report now, and this is part of the record. It is required that we consider the information in this report

FORM RR-125 REPORTERS PAPER & MFG. CO. 800-626-6313

in our review in preparation of the final impact statement.

MR. MAGUIRE:

Well, one of the important things that I want to find out, sir, is --

Let me have my copy of the report.

(Whereupon, a document was presented to Mr. Maguire by a member of the audience)

-- is who and under what circumstances it was determined that ---

On page 169 of your report, "Representatives of the citrus industry in the Lake Apopka area reveiwed Bartholic and Bill's findings and requested that further studies of the frost/freeze problem be done."

This is what I'm interested in finding out.

"DER and EPA's carefully considered this request and concluded that further investigations would not likely produce additional benefits."

Ultimately, I'm going to need to know who were the bodies that went through the mental process that arrived at that conclusion, and what were their technical bases for deciding there wasn't any further need, because unless they're better qualified than Dr. Bartholic, we're going to get into a factual confrontation at some level over who can make those kind of determinations.

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MR. HOWARD:

In all cases of a technical nature, you can have differences of opinion and ---

A VOICE:

Can't hear you.

MR. HOWARD:

In all cases where you have very technical kinds of questions, such as this one, you can have differences of positions, and in this particular case, the statement that you have read represents both the Environmental Protection Agency's position, which the study was reviewed by our Air Programs group -- who has meteorologists; we have our own experts -- and were reviewed by the Department of Environmental Regulation, and that statement does represent the opinion of the EPA and DER.

MR. MAGUIRE:

I recognize that that would be the answer I would get, and I don't want to argue with you. I just want to know whether those men or women, whichever the case may be, comprehend Florida agriculture and Florida temperatures and meteorology as it pertains to that very narrow geographical subject area. Thank you, sir.

MR. LITTLE:

Those questions will be answered, along with any others that were asked tonight.

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I would call the name again of Mr. Mac Bleakley. Has he returned to the room, and would he like to speak?

(No response)

MR. LITTLE:

Would any of the previous speakers like to make further comment?

(No response)

MR. LITTLE:

In that event, ladies and gentlemen, I think we have reached the end of the public hearing aspect of this Draft Environmental Impact Statement.

A few words on what happens now. You have until April 26th to submit any further comments in writing to the address previously given you of Mr. John Hagan. That address is listed on your agenda if you didn't happen to write it down. We have additional copies in the back.

We will be spending a lot of time between now and the time that a final impact statement is prepared reviewing your comments tonight. I know that there has been a lot of public meetings, perhaps as much input from the public in this particular project as any that I'm aware of, and I would again commend the Department of Environmental Regulation and Jean and the consulting firm for the work that they have done.

The information that is in the Draft Environmental

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Impact Statement in this particular project is similar to that in other impact statements that are prepared. There is a design considered, presented and discussed. Rarely does it turn out to be a final design, if a project is approved, and adjustments certainly can be made, if the approval is forthcoming, to move ahead with this alternative that has been discussed tonight or any other, so I would ask you that have additional comments, and perhaps you do, please submit them to us.

I see one hand raised, and perhaps there's a question. Would you --- Excuse me?

MR. SHERMAN:

I'd like just about a minute, if I could, before you close.

MR. LITTLE:

Yes, sir. Come right down and identify yourself.

MR. SHERMAN:

I'm R.W. Sherman from Killarny Court on Lake Apopka, Killarny Florida, and my only comment is that I hope that the people that have been -- may I use the word detractors to the proposed drawdown -- that rather than they just forget ---

I have lived on Lake Apopka for thirty years, thirty-one years plus. Back in 1952, I would guarantee anybody a limit of bass in four hours. I don't ever expect to

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see that again in my lifetime. I don't plan on living on Lake Apopka that much longer, but I certainly hope that those of you that have been detractors to the program, remember that the heritage of a 50 square mile lake that was nationally known as a fishing source will try to, not just detract, but add to some means by which improvement can be brought to the lake.

And furthermore, I would like to comment that even though the price has gone up some $6 million, you must not forget that the taxpayers and the people who live around Lake Apopka have already spent in the vicinity of $9.5 million in clearing up this pollution situation, so that the lake might be improved.

And it would be a crying shame not to finish the job when you have an opportunity. Maybe this is the wrong way, but it's the best looking way we've seen so far, and don't just cross Lake Apopka off for whatever particular reason you have. Our pollutants are going to keep on going downstream, getting to those other lakes, because they are still in Lake Apopka unless something's done to reverse the situation; they're going to continue and continue, and I thank you.

(Applause)

MR. LITTLE:

Thank you. A comment was made a minute ago, or

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rather a question, on whether or not we were aware of the temperatures in Florida, and those of us that are up here with our coats on and otherwise, I think are all aware of it. It's a little warm this evening.

I'd like to thank you very much for coming. Again, please submit your comments. That's why we're holding the hearing. If you don't think that you know enough technically about what's happening, submit it anyway. That's the kind of question that we're required to answer when we prepare the final statement. Thank you very much and good evening.

(Whereupon, at 9:05 p.m. the hearing was concluded)

FORM RR-125 REPORTERS PAPER & MFG CO 800-626-6313

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## C E R T I F I C A T E

This is to certify that the attached proceedings before THE ENVIRCMENTAL PROTECTION AGENCY, REGION IV in the matter of:

Lake Apopka Restoration Project
Lake and Orange Counties
Tavares, Florida

Agriculture Center Auditorium
Tavares, Florida

7:30 p.m.

April 10, 1979

were held as herein appears and that this is the original transcript for the file of the Agency.

**ANNE JAPOUR**
Official Reporter

-oOo-

## Responses to Comments and Questions Raised at Public Hearing

1. Response to Charles F. Beaver:
   No response necessary.

2. Response to John A. Carlin:
   No response necessary.

3. Response to Neil R. Greenwood:
   Mr. Greenwood's proposal to divide Lake Apopka into four sections with earthen dikes and draw down each section independently was seriously considered by DER. However, many of the concerns and adverse impacts of the RSB&W drawdown design also apply to the Greenwood proposal. A detailed analysis of the sectioned drawdown technique is included in Appendix C - Alternative proposals. The reader should refer to that appendix for further information.

4. Response to Herbert Zebuth:
   The drawdown of Lake Apopka has been designed to minimize the discharge of highly nutrient-rich, sediment-laden water to downstream lakes. The in-lake sedimentation basin is designed to remove over 90% of the suspended solids before the water leaves Lake Apopka. In addition, Lake Beauclair will act as a secondary basin to trap any sediments that do leave Lake Apopka. This topic is addressed in great detail in Section 4 - under Biological and Chemical Concerns. Further information can also be found in Section 7 - under Responses 2, 3, and 14. Basically, the adverse effects of nutrients and sediments on downstream lakes is expected to be temporary and insignificant.

   The problem of terrestrial weed growth and uprooting has been addressed in this Final EIS. These weeds will benefit the consolidation of the exposed lake bottom but are expected to die and decompose upon refill. The contribution of nutrients from these plants and expected effects on water quality and reestablishment of aquatic macrophytes are discussed in Section 4 - under Biological and

Chemical Concerns. Further research is needed to more accurately estimate the effect of these decomposing plants. Removal of the terrestrial weeds with current harvesting techniques would cost more than $10,000,000 and could damage the newly consolidated lake bottom. Therefore, weed removal is not deemed feasible.

Hydrilla is not expected to present a major problem in Lake Apopka if the drawdown is implemented. This aquatic plant is not found in Lake Apopka now and is not a problem species in any of the lakes in the Oklawaha Chain. The possibility does remain, however, that it could become established after refill. The proposed test drawdown would study the reestablishment of aquatic macrophytes after refill, including hydrilla. These studies could analyze the potential for hydrilla infestation following drawdown, as well as expected growth rates for all other aquatic macrophytes.

Sediment consolidation is essential to the success of the proposed drawdown and was studied in detail by the consulting engineers. The results of these studies indicate that consolidation causes primarily physical, irreversible changes in the muck; these changes are expected to last for at least seven years, if not indefinitely (RSB&W, 1978). Therefore, the engineers are confident that consolidation will be successful and long-lasting and will improve the lake bottom significantly. The major problem encountered in this aspect of the project relates to the 30% of the lake bottom that will not be consolidated. Soils engineers have estimated that the water level must be at least 0.3 m (1.0 ft) below the muck for significant consolidation to occur. Thus, although approximately 85% of the lake bottom will be exposed, only 70% will experience consolidation. The remaining 30% may eventually become redistributed over the lake bottom due to wind and wave action. The effect of such redistribution on the success of the project is unknown and is a major reason for the recommended test drawdown.

Appendix A contains a detailed discussion of the muck consolidation studies performed by the consulting engineers. The reader should refer to this appendix for more information on the results of those studies.

5. Response to Bert Roper:
No response necessary.

6. Response to Edward Scheer:
The "no action" alternative has been readdressed in this Final EIS and given substantially more consideration. A discussion of this alternative and its advantages and disadvantages is contained in Section 3 - Alternatives. A specific benefit-cost ratio was not identified in the Draft EIS because the impacts of the drawdown are not fully understood. It is impossible to predict a dollar value for beneficial effects of a project when the extent and longevity of those benefits are unknown. Therefore, a range of values was calculated for a variety of post-drawdown conditions. This method was the only reasonable way to estimate the benefits and costs of the project. No overestimation of benefits or underestimation of costs was deliberately contrived by any staff member in the writing of the benefit-cost analysis. As stated in the Final EIS, further documentation of the specific effects of the drawdown on Lake Apopka is necessary before a more accurate comparison of benefits and costs can be completed.

The effect of the proposed drawdown on downstream lakes has been discussed previously in this document under Sections 4 and 7. The drawdown method of lake restoration is still experimental in that results vary from lake to lake. Since the impacts of drawdown on Lake Apopka were based on a limited data base, the Final EIS recommends further studies and a test drawdown. The results of these studies should produce enough information that, if and when a drawdown is performed on Lake Apopka, it will not be experimental.

7. Response to Kenneth C. Sedlak:
Further study of the various problems associated with extreme drawdown of Lake Apopka is needed. While this research progresses,

however, monitoring of water quality in Lake Apopka and the downstream lakes should continue. Such monitoring will further document the condition of these lakes and will identify any important trends in water quality. In this manner scientists can determine what effects Lake Apopka has on the condition of the downstream lakes.

8. Response to C. E. Heppberger:
As previously discussed, the consulting engineers have conducted extensive muck consolidation studies which indicate that the muck will undergo an irreversible change and that the lake bottom will be improved through consolidation. The proposed drawdown would produce a firm crust over 30% of the lake bottom and an improved crust over another 40% of the lake bottom. Thus, it is not the consolidation process that is of greatest concern to project analysts. It is the restrictive time frame, adverse biological effects, and the unconsolidated muck remaining after refill that need further study. These concerns have been expressed in detail in Section 4.

Mr. Heppburger's recommendations for nutrient abatement, enhanced fluctuation, haul seining of rough fish, and perfection of the dredging alternative have also been addressed in this report under the Selected Alternative. Specific consideration of the dredging alternative is contained in Section 3 and Appendix C.

9. Response to Raymer F. Maguire, Jr.:
No probability of success for the project has been calculated because current data on lake drawdowns vary considerably. The success rate of this project will depend on numerous factors, including the degree of muck consolidation, weather conditions, and construction schedules. In addition, because of the unknowns involved in this project, the ultimate benefits of this drawdown are not currently predictable. It is hoped that the results of the recommended test drawdown will eventually permit the calculation of a probability of success.

Mr. Maguire's concern over the frost/freeze protection dilemma of the proposed project was included in a written comment to EPA. A response to this comment and a detailed explanation of the citrus protection aspect are included in Section 7 - under Response 20.

## SECTION 9
## LITERATURE CITED

Anderson, W. 1970. Hydrologic considerations in draining Lake Apopka: A preliminary analysis. U.S. Geological Survey (Mimeo).

Bartholic, J. F., and Bill, R. G. 1977. Freeze study for Lake Apopka vicinity, Phase I and II (Report to Florida DER and EPA). IFAS, University of Florida, Gainesville, Florida.

Berner, R. A., 1971. Principles of Chemical Sedimentology. McGraw-Hill.

Biederman, C. A., 1978. Phytoplankton Identification in the Upper Ocklawaha Lakes. Abstracts to Florida Academy of Sci. meetings, Orlando, April 14, 1978. Florida Scientist 41 (Suppl.): 24.

Brezonik, P. L., C. D. Pollman, T. L. Crisman, J. N. Allison, and J. L. Fox, 1978. Limnological studies on Lake Apopka and the Oklawaha Chain of Lakes: 1. Water Quality in 1977. Report No., ENV-07-78-01. Department of Environmental Engineering Sciences, University of Florida, Gainesville, Florida.

Clark, E. E., 1976. Effects of lowering Lake Apopka on citrus groves. Report of Edward E. Clark Engineers - Scientists Consulting Firm, South Miami, Florida

Davis, S. M. and L. A. Harriss. 1978. Marsh plant production and phosphorous flux in Everglades Conservation Area 2. In: Environmental Quality through Wetlands Utilization, M. Drew, ed. Tallahassee, Florida.

Dunst, R. C. et al. 1974. Survey of lake rehabilitation techniques and experiences. Wisconsin Department of Natural Resources Bulletin No. 75, Madison, Wisconsin.

East Central Florida Regional Planning Council. 1972b. Water Management. Winter Park, Florida

Fast, A. W. 1975. Artificial aeration and oxygenation of lakes as a restoration technique. In: Recovery and restoration of damaged ecosystems, J. Cairns, Jr., K. L. Dickson, and E. E. Herricks, eds. University Press of Virginia, Charlottesville, Virginia.

Florida Department of Pollution Control. 1971. Lake Apopka water quality improvement program. Florida DPC, Tallahassee, Florida.

Florida Department of Pollution Control. 1972. Lake Apopka restoration project, project plan. Florida DPC, Tallahassee, Florida.

Florida Game and Fresh Water Fish Commission. 1974. Lake Tohopekaliga drawdown study. Completion report, F-29.

Florida Game and Fresh Water Fish Commission. 1978a. Lake Carlton Rehabilitation Evaluation July 1, 1977 to June 30, 1978.

Florida Game and Fresh Water Fish Commission. 1978b. Lake Tohopekeliga drawdown and long-term fishery management proposal; Kissimmee, Florida.

Fox, J. L., P. L. Brezonik, and M. A. Keirn. 1977. Lake drawdown as a method of improving water quality. EPA Ecological Research Series. EPA-600/3-77-005. Washington, D. C.

Hahn, 1977. Ecological study of the proposed Lake Apopka drawdown and restoration (Draft). Camp. Dresser and McKee Environmental Sci. Div., Milwaukee, Wisconsin.

Hargrave, B. T. 1973. Coupling carbon flow through some pelagic and benthic communities. J. Fish. Res. Bd. Canada, 30:1317-1326.

Holcomb, D. E. and W. L. Wegener. 1974. Response of floodplain vegetation to lake fluctuation. Fla. Sci., Quart. J. Fla. Acad. Sci. 36pp.

Manheim, F. T. 1970. The diffusion of ions in unconsolidated sediments. Earth Plan. Sci. Letters, 9:307-309.

National Eutrophication Survey. 1976. Preliminary report on Lake Apopka, Orange and Lake Counties, Florida. EPA Region IV. PNERL, Corvallis, Oregon and NERC, Las Vegas, Nevada.

Patriquin, D. G. and C. Keddy. 1978. Nitrogenase activity (acetylene reduction) in a Nova Scotian salt marsh: Its association with angiosperms and the influence of some edaphic factors. Aquatic Botany, 4:227-244.

Patriquin, D. G. and R. Knowles. 1975. Effects of oxygen, mannitol, and ammonium concentrations on nitrogenase ($C_2H_2$) activity in a marine skeletal carbonate sand. Marine Biology, 32:49-62.

Pollman, C. D. and D. L. Brezonik. 1979. Nutrient characterists and nutrient exchange dynamics of Lake Apopka sediments. Progress report to Florida Department of Environmental Regulation. Department of Environmental Engineering Sciences, University of Florida, Gainesville.

Ross, Saarinen, Bolton, and Wilder; Environmental Engineers. 1978. Lake Apopka restoration project, preliminary final engineering report. Clearwater, Florida

Sargent, F. O. 1976. Land use patterns, eutrophication, and pollution in selected lakes. Vermont Water Resources Research Center and U.S. Department of Interior.

Southwest Florida Water Management District. 1976. Report on the streamflow and fluctuation of the Oklawaha River and Oklawaha Chain of Lakes.

Stewart, W. D. P., G. P. Fitzgerald, and R. H. Burris. 1967. In situ studies on $N_2$ Fixation using the acetylene reduction technique. Proc. Nat. Acad. Sci., 58:2071-2078.

Tuschall, J. R., T. L. Crisman, P. L. Brezonik, J. N. Allinson. 1979. Limnological studies on Lake Apopka and the Oklawaha Chain of Lakes: 2. Water Quality in 1978. Report No. ENV-07-79-02. Department of Environmental Engineering Sciences, University of Florida, Gainesville, Florida.

United States Department of Commerce. 1978. Survey of current business. Bureau of Economic Analysis, 58(4): 5-10.

Wetzel, R. G. 1978. Limnology. Sanders, Inc. Philadelphia, Pennsylvania.

# APPENDIX A

# SEDIMENT CONSOLIDATION STUDIES

# SECTION 4

# CONSOLIDATION OF EXPOSED LAKE BOTTOM

## 4.01 INTRODUCTION

The purpose of the entire drawdown project is to expose the lake bottom so that consolidation of the muck deposits can be achieved. The viability of the total restoration project is directly dependent upon (1) the extent to which the exposed lake bottom will consolidate during the drawdown and holddown and (2) the length of time the bottom will remain consolidated after refill.

Therefore, a study was performed to:

(1) predict what portion of the lake bottom will consolidate,

(2) predict the degree of consolidation,

(3) estimate the length of time the sediment will remain consolidated,

(4) estimate the influence the growth of vegetation will have on the lake bottom consolidation,

(5) recommend whether the drawdown will have a significant beneficial effect on the sediments and Lake Apopka.

This section presents the findings, conclusions and recommendations of that study. Detailed technical discussion is included in Appendices A, B, C and D.

## 4.02 LITERATURE REVIEW

Available literature on the condition and testing of Lake Apopka muck, the results and effects of lake drawdowns in Florida, and information on other weak soil deposits (i.e., phosphate slimes) were reviewed. This led to the following conclusions:

(1) Lake drawdown has proven a successful method for improving soft-bottom conditions in other lakes, both in Florida and elsewhere.

(2) Exposure to the sun and atmosphere can dramatically consolidate the Lake Apopka muck; this consolidation appears to be irreversible upon resubmergence.

(3) Muck and peat behave differently, with the peat much less likely to derive a permanent benefit from consolidation after drawdown.

(4) Consolidation causes primarily physical, rather than chemical and biological, changes in the muck.

(5) As yet, geotechnical engineers have not become involved in evaluating the Lake Apopka muck consolidation problem.

(6) No large-scale muck consolidation field tests have been performed, and no tests of any kind have been performed on muck that retained its natural structure. While the many previous drying tests of Lake Apopka muck did produce useful information, all had serious flaws when attempting to extrapolate them to a behavior of a 50 square mile lake.

(7) Virtually no quantitative information exists concerning the engineering strength, permeability and compressibility properties of the Lake Apopka muck.

## 4.03 CONSOLIDATION STUDY

### A. Lake Apopka Field Work

During the course of this study, 36 static cone muck penetration tests were performed *in situ* on Lake Apopka. Because of the muck's extremely low strength, cone testing required the use of a special, zero buoyant weight penetrometer which could be accurately loaded under field conditions. The objective of this testing was to define muck surface elevation, strength and thickness. The results provide a quantitative basis for comparing muck properties within Lake Apopka with other lakes, and also provide a basis for comparing undisturbed samples. Sample dates, locations and force depth logs can be found in Appendices A and B.

To preserve the fragile, natural structure of the muck, an adapted Swedish 50 millimeter fixed piston sampler was used to obtain undisturbed muck samples. Eleven unconsolidated samples were obtained. In general, recovery ratios were high; samples appeared in excellent condition and were subsequently used for laboratory analysis. Details pertaining to the dates and locations of undisturbed samples can be found in Appendices A and B.

### B. Comparative Field Work

Comparative field work was performed at several nearby lakes which have been previously drawndown. This field work is summarized below.

#### 1. Lake Tohopekaliga

A significant muck thickness was found in Friar's Cove; and four static cone soundings and two undisturbed samples were obtained. Muck at these locations should have been exposed as much as 2.0 feet above the lake drawdown level. The sounding-logs (Appendix B) appear to show a definite crust formation at three of the four sounding locations. However, muck found at the Friar's Cove site appears denser and stronger than the Lake Apopka muck, and it is possible that the apparent crust formation may result from a sandier muck at the "crust" level. No more than six inches of muck was found in the rest of Lake Tohopekaliga.

#### 2. Lake Kissimmee

No more than six inches of muck was found in Lake Kissimmee. This small thickness was not sounded or sampled.

#### 3. Lake Carlton

Thick muck was found under much of Lake Carlton. Part of Lake Carlton was cross-sectioned with 23 cone soundings. Details of the profile can be found in Appendix B.

### C. Laboratory Consolidation Tests

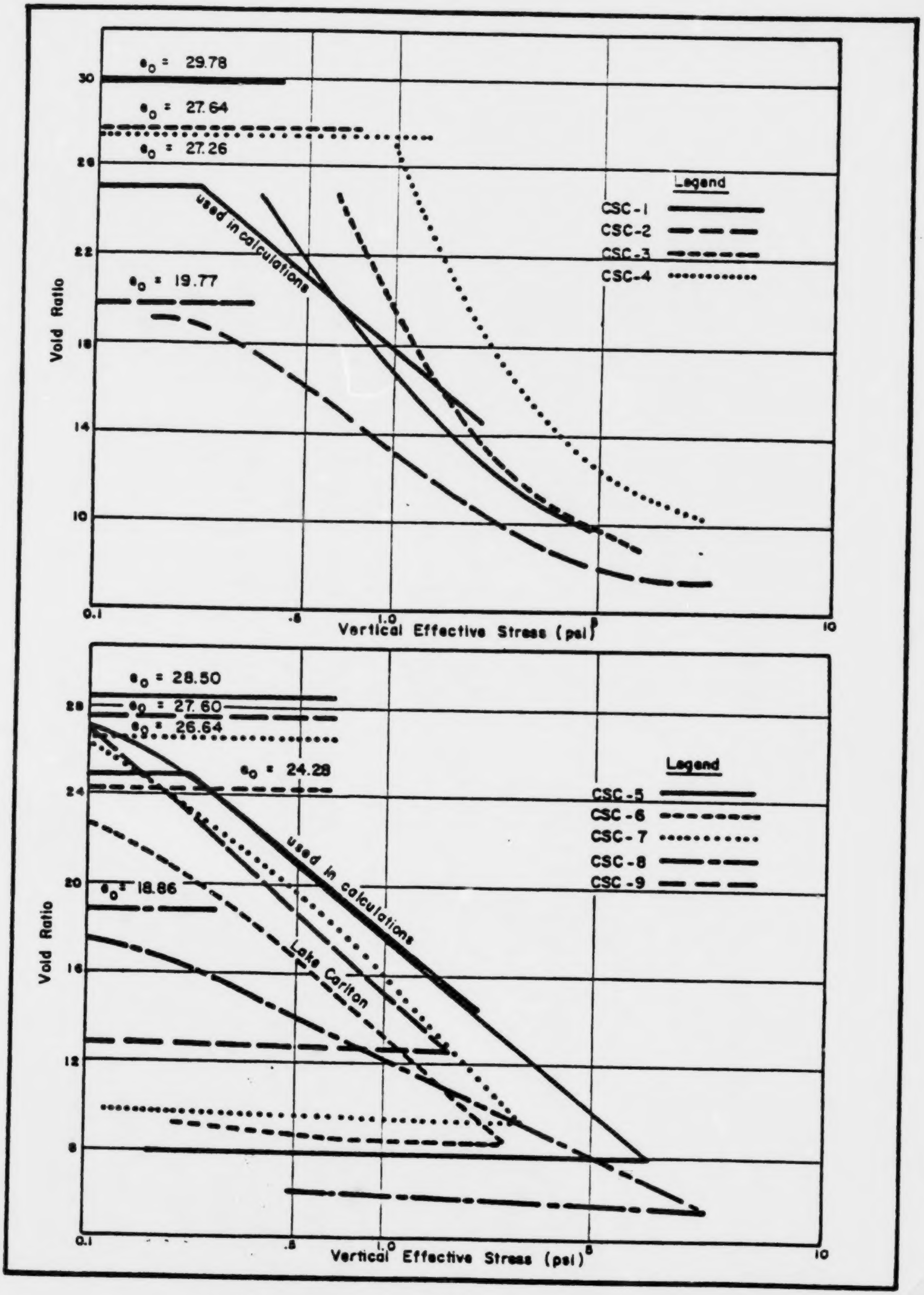
Ordinary consolidation testing would not have been suitable for this extreme material. As a result, an electronically instrumented, constant rate of strain consolidation test was developed. This permitted accurate measurement of small pressures, and the larger deformations involved when testing this material. In addition, this test utilized undisturbed samples obtained with the fixed piston sampler. Further details pertaining to the consolidation test can be found in Appendices C and D.

Figure 4-1 presents the final, conventional effective stress-void ratio results from nine consolidation tests. Table 4-1 summarized the permeability and coefficient of consolidation results as computed from these test data.

## TABLE 4-1

## SUMMARY OF CONSTANT RATE OF STRAIN CONSOLIDATION TESTS

| Test Number | Lake | Effective Stress (psi) | Void Ratio (e) | Percent Solids (%) | Permeability k (in/sec) | Coefficient of Consolidation $c_v$ (in$^2$/sec) |
|---|---|---|---|---|---|---|
| CSC-1 | Apopka | 1.09 | 16.1 | 10.0 | $3.3 \times 10^{-6}$ | $2.1 \times 10^{-4}$ |
| CSC-2 | " | 0.96 | 13.4 | 11.8 | $1.1 \times 10^{-5}$ | $8.6 \times 10^{-4}$ |
| CSC-3 | " | 1.04 | 18.9 | 8.7 | $1.8 \times 10^{-6}$ | $9.4 \times 10^{-5}$ |
| CSC-4 | " | 1.08 | 25.2 | 6.7 | $5.3 \times 10^{-5}$ | $3.5 \times 10^{-3}$ |
| CSC-5 | " | 1.05 | 17.2 | 9.5 | $2.0 \times 10^{-6}$ | $2.1 \times 10^{-4}$ |
| CSC-6 | Carlton | 1.21 | 12.4 | 12.7 | $4.0 \times 10^{-7}$ | $3.6 \times 10^{-5}$ |
| CSC-7 | Apopka | 1.00 | 15.6 | 10.4 | $1.3 \times 10^{-6}$ | $8.7 \times 10^{-5}$ |
| CSC-8 | " | 1.13 | 11.8 | 13.3 | $2.4 \times 10^{-6}$ | $3.5 \times 10^{-4}$ |
| CSC-9 | " | 0.99 | 15.0 | 10.7 | $2.8 \times 10^{-7}$ | $2.5 \times 10^{-5}$ |
| Assumed average | | 0.2 | 25.0 | 6.7 | $2 \times 10^{-4}$ | $8 \times 10^{-3}$ |
| Values used in calculations | | 0.9 | 18.3 | 9.0 | $5 \times 10^{-6}$ | $3.3 \times 10^{-4}$ |



Partial summary of pressure vs. void ratio diagrams from constant rate of strain consolidation tests

FIGURE

It should be noted that these data do not show a large variation between consolidation properties of the various muck samples. This allows an idealized consolidation behavior, representative of all the muck, to be used in muck consolidation calculations.

### D. Special Drying Tests

Although other drying tests have been performed on Lake Apopka muck, results have been biased and flawed. For drying tests to be meaningful, the test must be designed to:

(1) test the muck with its natural structure,

(2) test the muck under one-dimensional drying conditions,

(3) keep the muck surface at the container surface during the test,

(4) test at the two extreme conditions of moisture access at the bottom of the sample,

(5) test at various sample heights above the ambient water table, and most importantly,

(6) allow sample and surface cracks to experience the effects of rainfall.

A special drying out test was designed with these restrictions in mind, and four samples of undisturbed muck were tested. To help insure one-dimensional drying, all parts of the samples above water were surrounded with styrofoam for insulation, and aluminum foil for radiation protection. Only the top plane of the sample could accept solar radiation energy and rainfall. A moveable plug supported the bottom of the sample; the plug was adjustable so that as drying and shrinkage occurred, the surface of the sample could be kept at the top of the liner. Bottom drainage was permitted in two of the four samples. Further details can be found in Appendix C.

Figure 4-2 and Table 4-2 summarize the results of these drying experiments. It was found that (1) solar radiation falling on a horizontal surface controls the drying rate, (2) rainfall interrupts this drying until water stored in the muck cracks can be evaporated, (3) the dried muck shows only a minor tendency to disintegrate when re-submerged, and (4) the muck dries to a final volume of about eight percent of its initial volume.

## TABLE 4-2

## SUMMARY OF RESULTS FROM SIMULATED ONE-DIMENSIONAL, SOLAR DRYING EXPERIMENTS ON LAKE APOPKA MUCK

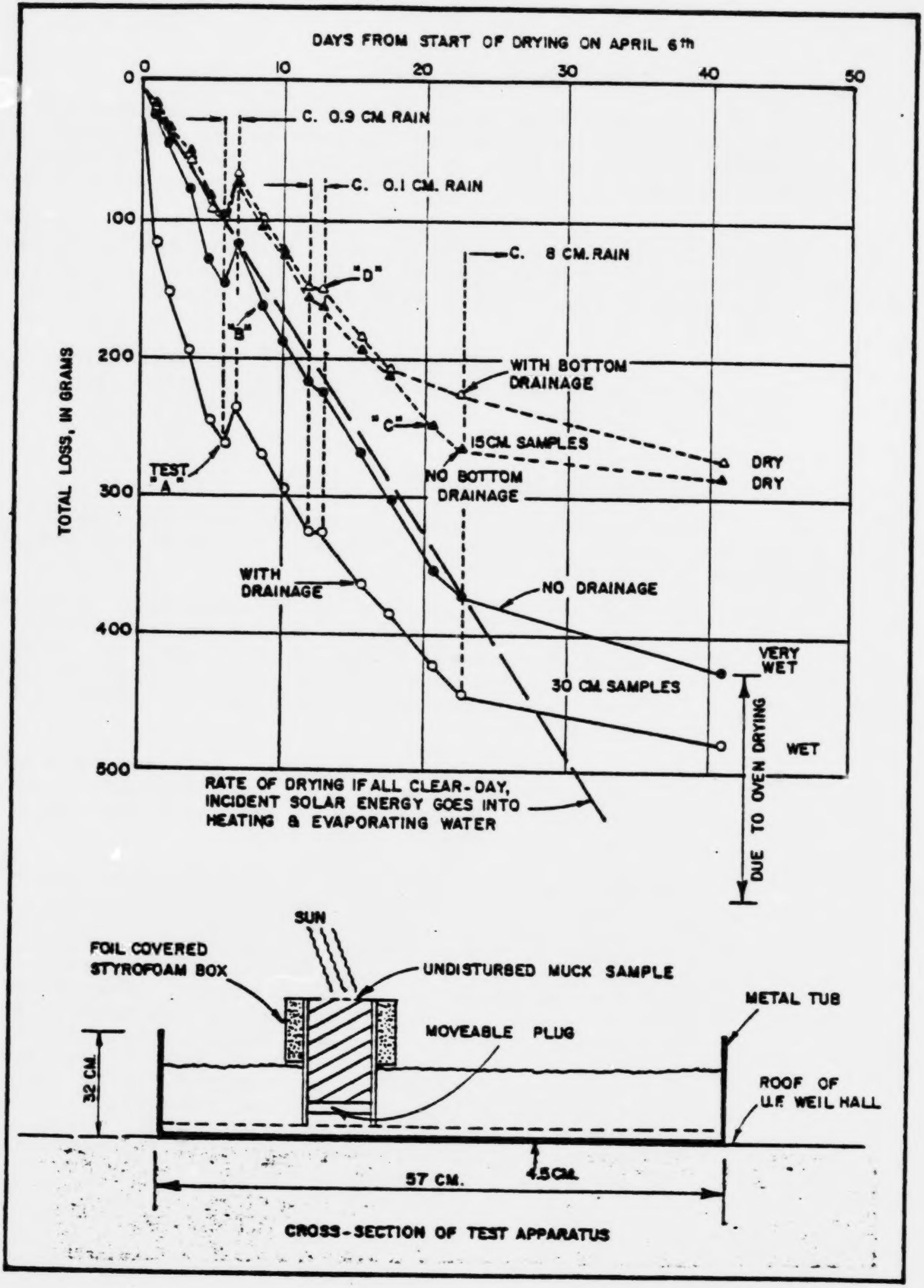
| Test | Apopka Sample | Initial Length (cm) | Bottom Drainage? | Sample Top Elev. (Feet MSL) | Initial Percentage of Solids | Water Loss/Water in Muck percentage in 5 days | 10 days | 23(1) days | 41(2) days | Percentage of Volume Loss |
|---|---|---|---|---|---|---|---|---|---|---|
| A | C4-2U | 30.0 | Yes | 60.1 | 8.0 | 46 | 56 | 84 | 91 | 80+ |
| B | B1-6U | 31.8 | No | 59.8 | 6.8 | 22 | 32 | 63 | 72 | 94 (in oven) |
| C | DCO-13U | 14.8 | No | 60.0 | 7.0 | 29 | 44 | 93 | 100 | 93 |
| D | D2-10U | 14.8 | Yes | 59.8 | 8.1 | 34 | 45 | 83 | 100 | 92 |

---

(1) End of daily data readings. Only approx. 1 cm rain during 1st 20 days.

(2) End of test. Approx. 8 cm rain in final 18 days.

Notes: All samples in 5.0 cm diameter plastic liners taken directly from undisturbed sampler.



One-dimensional muck drying experiments

FIGURE 4 - 2

E. Other Laboratory Tests

Twenty-five water content tests were performed on the Lake Apopka muck samples. Values ranged from about 2600 percent to 1000 percent on a dry weight basis. In terms of percent solids, this range equals about 4 percent to 9 percent.

Five specific gravity tests (four on undried samples and one after ignition at about 600°C) were performed. The pre-ignition test results ranged from about 1.7 to 1.9, and average 1.80. The one post-ignition specific gravity test was 2.62.

Seventeen post-ignition tests for weight loss were also performed. Results varied from about 53 percent to 73 percent of solids.

## 4.04 CONCLUSIONS AND RECOMMENDATIONS

Based on the previously described studies, the following conclusions and recommendations are offered for the Lake Apopka restoration project:

(1) Lake Apopka muck will consolidate with 30 percent of the bottom forming a hard crust, 40 percent showing improved firmness and 30 percent remaining unchanged. These various areas of muck consolidation and their characteristics are shown in Figure 4-3.

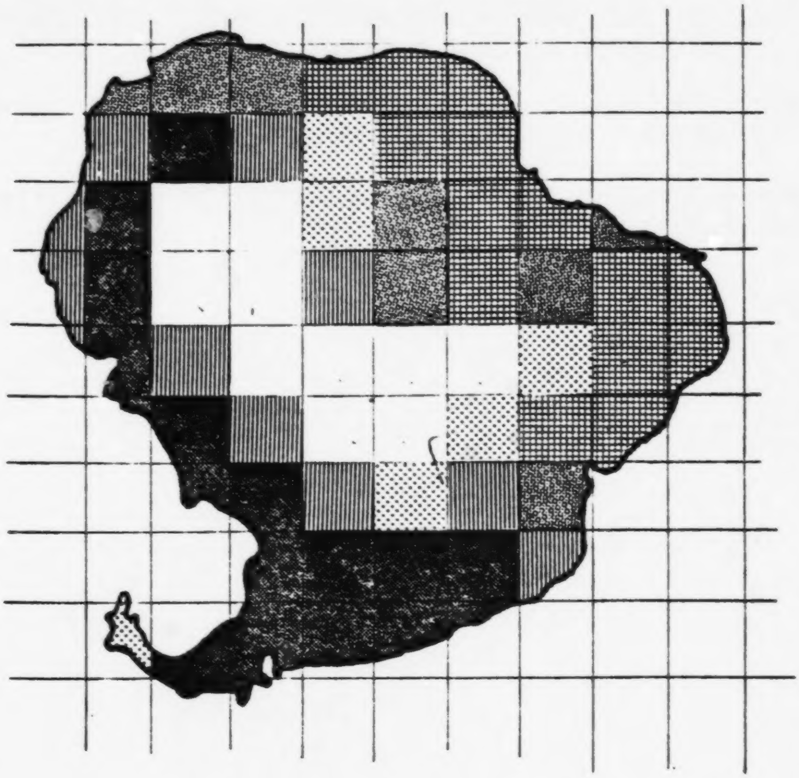
(2) Total muck consolidation will increase Lake Apopka's volume by approximately 13 percent. Eight percent of the volume increase is weather independent; five percent is weather dependent.

(3) Similar muck sediments at Lake Tohopekaliga have remained consolidated for seven years (1971 to present) and currently show little or no signs of weakening or resuspension. Consolidation causes primarily physical changes in the muck; these physical changes appear to be irreversible. Therefore, it is reasonable to expect Lake Apopka muck to remain consolidated for at least seven years, if not indefinitely. Whereas, accumulation of new muck on top of the hardened crust might diminish the effectiveness or longevity of the restoration project, previously discussed abatement of all point source pollution discharges will help to substantially minimize this possibility.

(4) Any new bottom vegetation will improve consolidation and reduce subsequent scout.

(5) The drawdown should have a definite beneficial effect on muck sediments.

These conclusions and recommendations are discussed in detail in Appendix C.



| Symbol in above | Consolidation conditions | Area mi.$^2$ | Muck consolidation settlement, average, feet | | |
|---|---|---|---|---|---|
| | | | Drying + | water squeeze = | total |
| □ | Muck surface less than +58.5 | 9.0 | 0.00 | 0.00<br>bottom still soft | 0.00 |
| ░ | Muck surface between +59 & +58 1/2 | 4.9 | 0.00 | 0.2<br>bottom still soft | 0.20 |
| ▦ | Muck thickness 1' or less, surface above +60 | 9.2 | 0.75 | 0.00<br>strong bottom crust | 0.75 |
| ▓ | Drawdown below bottom of muck | 5.4 | 0.6 | 0.25<br>strong bottom crust | 0.85 |
| ▥ | Muck thickness less than 6 ft. | 7.1 | 0.4 | 0.5<br>firm bottom crust | 0.90 |
| ■ | Muck more than 6 ft. | 12.7 | 0.15 | 1.25<br>slight bottom crust | 1.4 |
| | | 48.3 | | | |

Estimated muck consolidation behavior

# APPENDIX B

# RSB&W ENGINEERING DESIGN

# SECTION 6

# EVALUATION OF LAKE RESTORATION IMPACTS ON ORGANIC SOIL FARMS AND CITRUS GROVES

## 6.01 GENERAL

Agriculture and Lake Apopka are intimately related. These relationships and the proposed methods of protecting these relationships during the Lake Apopka Restoration Project are described in this section.

## 6.02 FROST/FREEZE PROTECTION

The "Freeze Study for Lake Apopka Vicinity, Phase I and II", commissioned by DER, concluded that one meter (approximately 3 feet) average depth in Lake Apopka will not significantly diminish the frost/freeze protection afforded to citrus growers south of Lake Apopka. With the results of this study, the following design constraints were prepared to insure adequate frost/freeze protection to the citrus groves.

(1) The lake level must be no lower than 64 feet MSL during December, January and February preceeding the drawdown.

(2) The lake level must be returned to 64 feet MSL by November 30th of the same year the drawdown is initiated.

These two constraints effectively require that the entire drawdown, holddown and refill be accomplished within a 9-month period. To achieve this goal, over $3,000,000 in additional facilities are required to accommodate higher flow rates.

Frost/freeze protection of citrus groves bordering on downstream lakes has also been considered. During the drawdown, holddown and refill of Lake Apopka, water levels in downstream lakes will remain within the regulatory limits as determined by the Water Management District. As such, the Lake Apopka Restoration Project will affect the frost/freeze protection offered by these lakes no more than what might result from any regulated lake fluctuation. However, it must be pointed out that during the winter months following the refill of Lake Apopka, the water levels in Lake Harris, Little Lake Harris, Beauclair, Dora and Eustis are projected to be at minimum desired elevations.

## 6.03 CITRUS IRRIGATION

The two objectives of this portion of the study were to:

(1) evaluate the extent to which the restoration project would impact irrigation needs of the citrus grower bordering the southern half of Lake Apopka, and

(2) determine what special provisions need be made to meet the demand for water.

### A. Irrigational Needs

The drawdown of Lake Apopka will have the following impacts on the irrigation requirements of bordering citrus groves:

(1) The water table in the vicinity of the lake will be reduced, possibly, under certain conditions, increasing the need for irrigation of the groves.

(2) Groves irrigated directly from the lake will "lose" their water source for much of the restoration period.

(3) Water levels in deep wells (utilized for irrigation) will be slightly reduced as a result of the drawdown of the lake.

To determine the extent of the water table decline produced by the lake drawdown, the analysis discussed in Section 5.08 B was conducted. This evaluation concluded that the areas in which the water table aquifer would be measurably impacted (greater than 0.1 feet decline from the "natural" water table surface) were estimated to extend landward from the lake about 2 miles to the south and about 1.5 miles to the east and west. Therefore, groves more landward of these limits will not be impacted and groves between the lake and the 1.5 - 2 mile limit will realize a lowered water table. The extent to which the irrigation needs of the groves will increase as a result of the water table decline is dependent upon (1) the degree to which the water table provides water to the trees; (2) the depth of the water table below the surface of the ground; (3) the soil type; and (4) the amount of water table decline induced by the drawdown. All of these factors are extremely difficult to assess, especially when studying such a large area. However, after considering the projected profile of water table decline, the elevation of the land surface, the time required to dewater the unconsolidated aquifer, and the relationship between the conditon of trees and water table, it was concluded that the groves within approximately 1000 feet of the lake would be impacted, and those more landward than 1000 feet would not, as a result of the drawdown, require additional irrigation water.

To evaluate the irrigation needs within the 1000 foot area, aerial photographs of Lake Apopka and vicinity were procured and the groves identified. Ownership of the groves was determined from Orange and Lake County tax rolls.

Grove owners were mailed questionnaires pertaining to their irrigation and management practices. A copy of this questionnaire is included in Appendix E. If after one month there was no response to the questionnaire, a duplicate was mailed. If the grove had been recently sold, a copy of the questionnaire was sent to the new owner.

Based on the responses to these questionnaires, field work, and confirmation visitations to many of the groves, citrus groves near Lake Apopka can be classified with regard to their irrigation practices as:

(1) groves which are irrigated from a deep well,

(2) groves which are irrigated from the lake, and

(3) groves which are not irrigated.

The location of citrus groves near Lake Apopka and the respective irrigation practices are shown in Figure 6-1. A detailed discussion of the provisions necessary for each category follows.

## B. Provisions to Provide Irrigation Water

### 1. Groves Irrigated from a Deep Well Tapping the Floridan Aquifer

The impacts of the Lake Apopka drawdown on the Floridan Aquifer have been previously discussed in Section 5.08. This analysis indicated that decline in the potentiometric surface would be so slight that the production capability of the wells would not be adversely impacted.

Groves within the 1000 foot band around the lake may experience increased irrigation needs, however, the existing irrigation systems could be used to supply the additional water.

### 2. Groves Irrigated from Lake Apopka

Many acres of groves are irrigated directly from the lake. Suction lines extend into the lake to supply water to irrigation pumps. Location of these pumps was determined from the questionnaires, field visits and a boat survey of the shoreline.

As the lake is drawn down, the suction lift on these pumps increases to the point that the pump can no longer lift the water into the pump. The critical lift is dependent upon type of pump, condition of pump and other factors. However, it may be assumed that during the restoration period, the pumps withdrawing water directly from the lake will fail due to either (1) increased suction lift, or (2) complete dewatering of the lake in the area of the pump.

Many techniques were evaluated to supply a water source to these pumps, so that the grove owner could irrigate per standard practices. The more promising approaches involved:

(1) Dredging a channel from deep holes or rim channels to the pump suction to provide a water source to the pump. This was judged unsatisfactory due to potential water quality and suction lift problems.

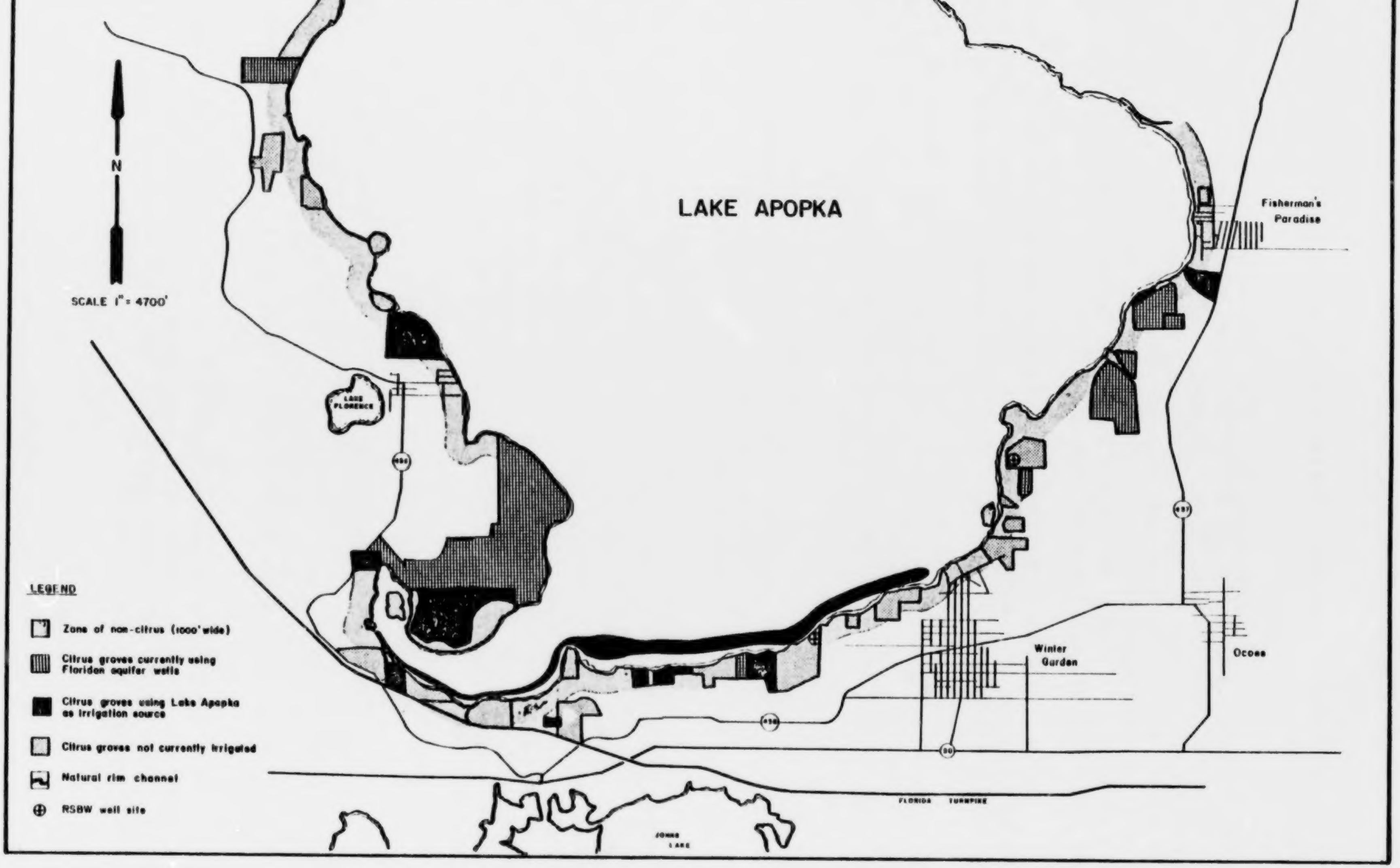
(2) Utilizing a water truck to irrigate the groves. This technique was deemed impractical due to cost and time-to-irrigate considerations.

To provide water to the irrigation pumps, a well tapping the Floridan Aquifer is proposed for construction. The well will be furnished with a deep well turbine pump and right angle gear drive. A portable trailer-mounted gasoline engine will provide power to the pump. The deep well pump will discharge directly into the existing irrigation systems. If, as a result of the drawdown of the lake, the groves require more water than would normally be required (due to a lowered water table), the irrigation systems only need to be used for a longer time.

### C. Groves Not Currently Irrigated

The groves that are not irrigated (see Figure 6-1) are of the greatest concern because of (1) the potential impacts associated with the lowering of the water table near the lake (as a result of the lake drawdown) and (2) the absence of an irrigational system to provide any additional water that may be needed.

Due to the excessive cost of installing, as a portion of the restoration project, an irrigational system in groves within the 1000 foot area directly landward from the lake, many alternatives were evaluated.


LAKE APOPKA
Fisherman's Paradise
N
SCALE 1" = 4700'
LAKE FLORENCE
455
438
50
437
Winter Garden
Ocoee
FLORIDA TURNPIKE
JOHNS LAKE
LEGEND
Zone of non-citrus (1000' wide)
Citrus groves currently using Floridan aquifer wells
Citrus groves using Lake Apopka as irrigation source
Citrus groves not currently irrigated
Natural rim channel
⊕ RSBW well site

Current irrigation practices of citrus groves within 1000 feet of Lake Apopka

FIGURE 6-1

First, a re-analysis was made of the probability that the lake drawdown would actually lower the water table enough to adversly impact the groves. The estimated lake stage (which is also the estimated water table level in the area most seriously impacted, i.e. directly landward of the lake) is shown in Figure 6-2. Also shown is the four month wet season (June-September) and the estimated water table level in the area most seriously impacted, i.e. directly landward from the lake. Several things can be noted. First, lowering of the lake will begin in September and, therefore, the water table will have six months to decline prior to actual pumped drawdown. Second, the wet season should provide sufficient water during the time the lake is at the lowest stage. Third, following the end of the wet season, the lake should be close to 64 feet MSL. Finally, the most critical period appears to be in late April and May. Unfortunately, this is when the size of the citrus crop is determined and irrigational needs are the greatest.

To confirm the distance to the water table, eight water table wells were constructed at the three sites shown on Figure 6-1. Results of this field program indicated that: (1) groves very close to the lake had a water table within four feet of the ground surface and (2) the water table was more than four feet below land surface under groves located more landward. As citrus typically grows on well drained soils and fulfills 90 percent of its moisture needs from the upper four feet of soil[2], the field observations in some near shore citrus groves indicated that the water table was close enough to the soil surface to be of concern.

Also, meetings were arranged with grove owners to discuss the impact of the Lake Carlton drawdown of 1977 on citrus groves. Grove owners stated that the citrus trees around Lake Carlton dropped about one half of their fruit. However, they noticed little or no decrease in fruit loss with increased distance from the lake. Due to the previous severe winter and a concurrent drought, it is impossible to estimate what portion of the crop loss was attributable to the Lake Carlton drawdown and what portion was due to stress caused by naturally occurring events (severe winter and severe drought).

In light of the meteorological conditions and the drawdown, the Lake Carlton drawdown probably represents a worst case situation with respect to the citrus groves. If the groves bordering Lake Carlton did not suffer disastrous loss as a result of the combined effects of the drawdown, drought and previous severe winter, there is little reason to believe groves bordering Lake Apopka will fare much worse. However, there is a significant probability that those groves close to the lake may be stressed due to water table decline. Although this probability may be very low, provisions must be made for irrigation water.

To minimize the impact of the lowered water table on the fruit yield and, more importantly, to assure the survival of the unirrigated groves during an extreme drought concurrent with the drawdown of Lake Apopka, several irrigation systems were evaluated:

(1) Velocity guns mounted on portable risers

(2) Towed water tank truck system

(3) Permanent irrigation systems

(4) Land application via perforated pipe

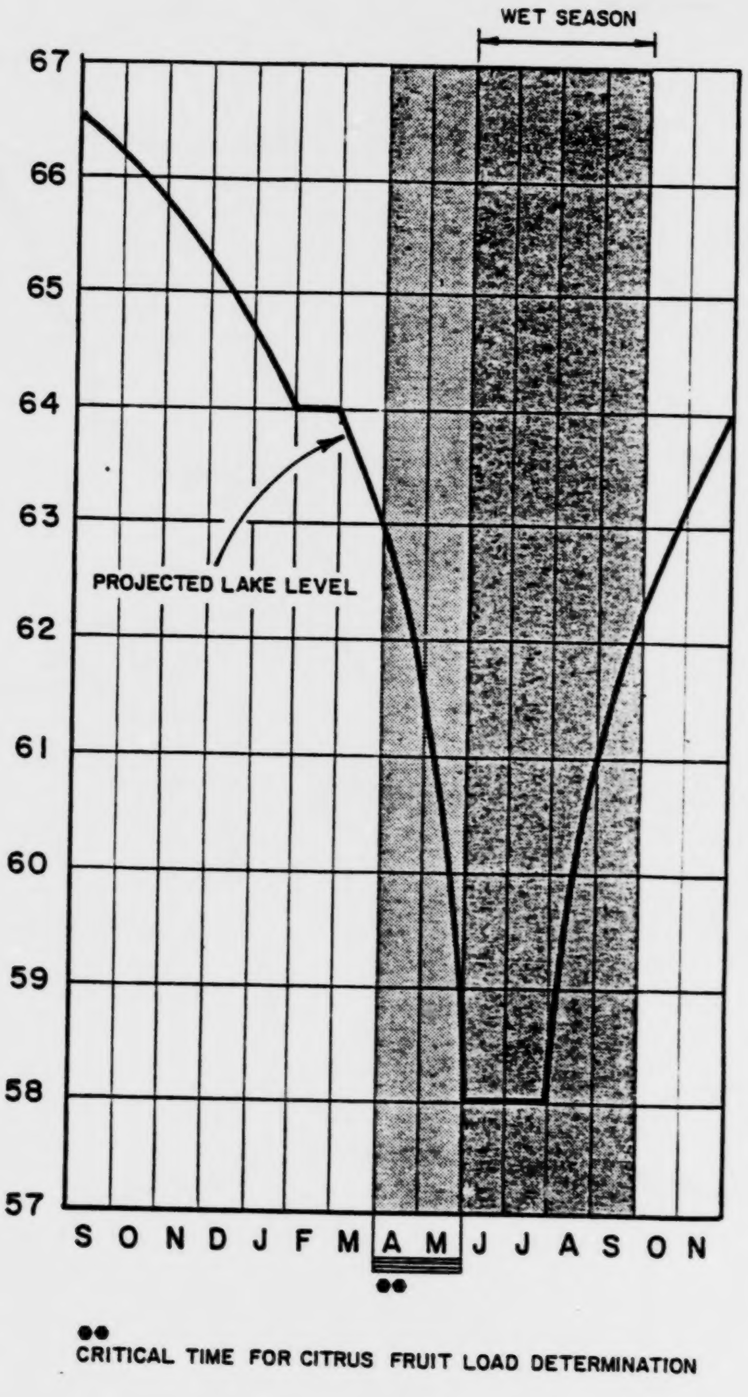
(5) Self propelled traveler system

The analysis indicated that the most reliable and cost effective irrigation system was the velocity gun mounted on a portable riser. Such velocity guns on portable risers will be located and relocated by truck as necessary. Wells will be drilled to supply water. The risers will be connected to the well pumps by aluminum pipe with bayonet type quick couplers and flexible, non-stretch hose. This system will be capable of providing sufficient water to existing unirrigated groves to mitigate the impacts of the drawdown.

Because ownership and irrigation practice of a given grove is subject to change any time, many specifics, (such as riser location, well location, etc.), must be determined immediately prior to drawdown. During the initial construction phase, the contractor will designate where the velocity guns on portable risers will be located, taking into consideration factors such as soil type, topography, grove condition and age, depth to water table, etc. Exact well locations will be based on accessibility, grove practice at the time of the project, irrigation status of adjoining groves, etc. For specifics on citrus irrigation, check the Drawings and Specifications.

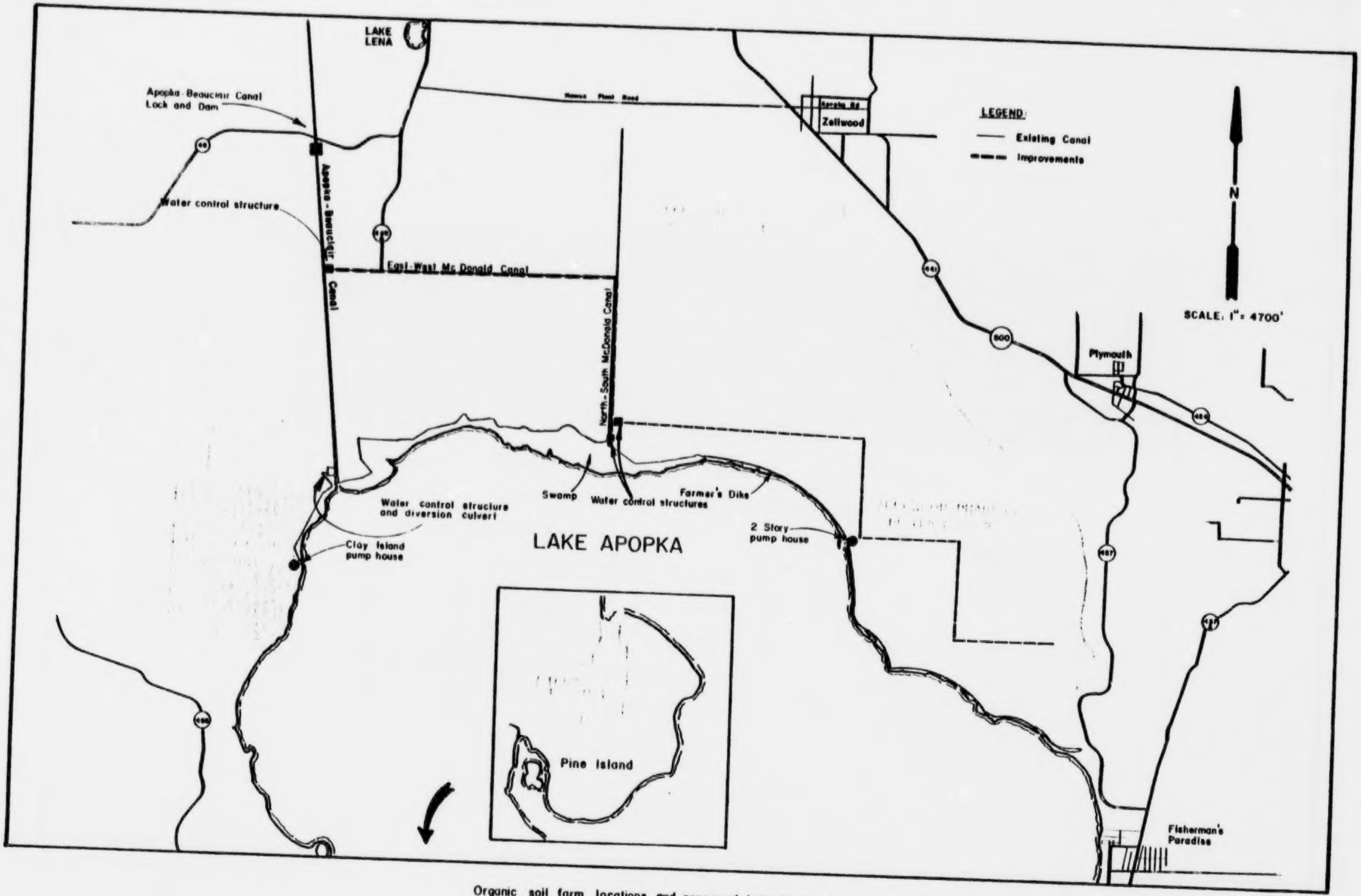
## 6.04 MUCK FARM IRRIGATION

Muck (organic soil) farmers to the north of Lake Apopka utilize water from Lake Apopka and the Apopka-Beauclair Canal to irrigate and flood their fields. During the drawdown, holddown and refill periods of the project, the farms will be supplied with water from the Apopka-Beauclair Canal (see Figure 6-3) through a series of improved canals. The contractor will provide several mobile pumps to apply water from the canal to those fields which normally irrigate and/or flood by gravity. Interior farms (those which do not flood by gravity)



Projected Lake Stages During Project Duration

FIGURE 6-2


LAKE LENA
Apopka-Beauclair Canal Lock and Dam
Water control structure
Apopka-Beauclair Canal
East-West Mc Donald Canal
North-South McDonald Canal
Zellwood
LEGEND:
Existing Canal
Improvements
N
SCALE: 1" = 4700'
441
500
Plymouth
Water control structure and diversion culvert
Clay Island pump house
Swamp
Water control structures
Farmer's Dike
2 Story pump house
LAKE APOPKA
Pine Island
Fisherman's Paradise

Organic soil farm locations and proposed irrigation system

FIGURE 6-3

can irrigate as they normally do. An in-depth study of muck farm irrigation is discussed below. For additional details, see the Drawings and Specifications.

### A. Zellwood Drainage District

Farms within the Zellwood Drainage District Units Number 1 and 2 currently take water for irrigation from the North-South McDonald Canal and Lake Apopka. Similarly, excess water, resulting from rainfall, seepage, etc., is pumped out of the muck farms into the North-South McDonald Canal and Lake Apopka. Canals which are used to transmit and distribute water into the farms are used at other times to remove water from the farms. Improvements in the canal system to provide irrigation water must be designed within this constraint.

In deriving design flows, water balance, existing pump capacities and average acreage demands were considered. Canal improvements (shown in Figure 6-3) were sized to keep head loss in the improved canals within acceptable limits. Specific data on the extent of canal improvements can be found in the Design Notebook and the Drawings and Specifications.

Water will be supplied by gravity to the improved District Canal from the North-South McDonald Canal through two 60-inch corrugated metal culverts. Screw gates will be attached to the culverts to control the flow. The water control structure is shown in Figure 6-3. Improvement will also be made in the East-West McDonald Canal and North-South McDonald Canal to provide a sufficient gravity of water to the farms. Flow into the East-West McDonald Canal from the Apopka-Beauclair Canal will be controlled by a dam and four 60-inch diameter culverts with screw gates (see Figure 6-3). Water level in the East-West McDonald Canal and North-South McDonald Canal will be controlled by operating the screw gates and by adjusting two 60-inch flashboard risers and/or two 60-inch culverts with screw gates which will be located at the south end of the North-South McDonald Canal. For an in depth study, refer to the Drawings and Specifications.

### B. Duda Farms

Presently, these muck farms are irrigated by canals connected directly to the Apopka-Beauclair Canal or to the East-West McDonald Canal (which is connected directly to the Apopka-Beauclair Canal). In this case, the water supply is not diminished by the restoration project and as a result, no alternative plans are necessary.

### C. Frank Farms

Frank Farms are irrigated directly from the Apopka-Beauclair Canal. Therefore, no alternative plans are necessary.

### D. Clay Island Farms

Clay Island Farms are currently irrigated from existing perimeter canal (west of the Apopka-Beauclair Canal) which is, in turn, connected with the Apopka-Beauclair Canal and Lake Apopka. During the restoration project, water will be supplied to Clay Island Farms at the northeast corner of their property (see Figure 6-3). Water from the north side of the Lake Apopka pumping station will be allowed to flow by gravity through a 60-inch corrugated metal culvert with screw gate into Clay Island Farms. For a better understanding of this aspect, refer to the Drawings and Specifications.

### E. XXX Products (Pine Island)

XXX is predominantly a soil mining operation; muck farming is secondary. Pumps are run continuously to maintain water levels low enough so that soils can be mined. As a result, no shortage of water is foreseen for this site.

If a water shortage occurs at this site, several alternative supplies are available. Several capped artesian wells presently exist on site. These can be uncapped and pumped to provide necessary water. If necessary, a short canal could be dug from the existing pump site to an existing deep hole offshore from Montverde.

## 6.05 DIKE PROTECTION

Protecting the dikes along the north shore of Lake Apopka, along the Apopka-Beauclair Canal and along the North-South and East-West McDonald Canals is extremely important. Sections 9.01 and 9.12 give the specifics on geotechnical testing and surveying to be performed during the project and techniques that must be used to assure integrity of the dike.

## 6.06 CITRUS GROVES NEAR LAKE BEAUCLAIR

As is the case with the citrus groves surrounding Lake Apopka, those groves which are irrigated directly from Lake Beauclair and groves which are not irrigated will potentially be impacted by the drawdown and holddown of Lake Beauclair. Each is discussed below.

A deep well will be provided for those groves which currently use Lake Beauclair as an irrigation water source. Wells will be drilled where necessary and the well pumps which were installed and used at the groves near Lake Apopka will be relocated to the wells drilled near Lake Beauclair.

Due to the location of Lakes Dora and Carlton and the role they will have in minimizing the water table impact which will result from Lake Beauclair drawdown, only a minimum impact on groves which are not currently irrigated is expected. If necessary, these groves can be irrigated by using the previously described velocity guns mounted on portable risers, using either Lake Dora, Lake Carlton or a deep well as a water supply. The distance between the water supply and the point of application can be traversed by portable aluminum pipe.

# REFERENCES

1. Bartholic, J.F. and R. G. Bill, Jr. Final Report on Freeze Study for Lake Apopka Vicinity, Phase I and II Fruit Crops Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville. August 29, 1977.

2. Koo, R. C. J. The Distribution of Uptake of Soil Moisture in Citrus Groves. Proceedings of the Florida State Horticultural Society, Vol. 74, pp. 86-90. 1961.

# SECTION 9

# PROPOSED FACILITIES TO IMPLEMENT PLAN

## 9.01 GENERAL

The preliminary design of the proposed facilities has been previously described in the Preliminary Engineering Report. After notice to proceed, field work necessary to complete the final design was performed. Field work included aerial photography, topographic photo surveys, selected field topographic surveys of the various sites, water depth profiles and cross sections, diverse geotechnical exploration (including the use of Standard Penetration Test and the Static Cone Penetration Test), laboratory testing of soil samples and extensive field reconnaissance of all sites. The preliminary design was modified to reflect the additional information gained during the final design field work. Modifications were made as necessary to better protect the public, reduce cost and enhance the viability of various project components. In most cases, modifications made during the final design period are refinements of facilities' design and concepts proposed in the Preliminary Engineering Report, and as such, are in many ways identical. Major exceptions are discussed below.

1. The shape of the intake sedimentation basin was changed for more efficient removal of suspended muck.

2. Design of the pumping station cofferdams along the Apopka-Beauclair Canal was changed to account for very poor soil conditions at each of these sites. Vehicle access over the Apopka-Beauclair Canal Lock and Dam cofferdam has been prohibited for this reason.

3. Because of very poor soil conditions at the south end of the Dora Canal and resulting problems which would occur during construction, the subaqueous crossing of the Dora Canal was abandoned. To maintain boat traffic, the 84-inch pipe will cross aerially over the canal with the same vertical clearance as the railroad bridge.

4. The 84-inch corrugated metal pipe was replaced by 7/16-inch-thick walled, 84-inch-diameter steel pipe. In light of the high velocities and the high volumes associated with this pipeline, welded steel pipe was selected to provide maximum protection to the public. The ductility of steel pipe will help mitigate the differential settling which can be expected from the poor soils along the pipeline route; welded joints will maintain pipeline integrity.

5. At the Dead River Dam and Boat Lift, the cofferdam was changed from a double row of sheeting filled with suitable granular fill to a single row of steel sheet pile as to reduce the cost of the structure. A fork lift type boat lift was added to handle more effectively the number and diversity of boats passing through the Dead River.

6. The cofferdams between Lakes Beauclair and Dora and between Lakes Beauclair and Carlton were changed from double rows of sheeting filled with suitable granular fill to a single row of steel sheet pile to reduce cost.

7. The Willow Dike plan for muck farm irrigation was replaced by the plan to irrigate through improved interior canals (previously described in Section 6.04). The Willow Dike plan was abandoned because construction of the Willow Dike would (1) threaten the integrity of the Farmers Dike, (2) damage significantly the existing shoreline vegetation along much of the north shore of Lake Apopka and (3) be severely complicated by the poor soil conditions in the north shore area. Abandoning the Willow Dike plan affects the dike protection plans as described in the Preliminary Engineering Report. Final plans for protection of the dikes are disclosed in detail in Section 9.12.

The remainder of this section describes proposed facilities necessary to implement the restoration project. More information on these facilities can be found in Table 9-1 and the Drawings and Specifications. Discussion of some features common to many sites follows:

### A. Pumping Equipment

During the course of this project, two pumping facilities will be required during the drawdown and holddown phases and three pumping facilities will be required during the refill phase. Consequently, the most important equipment required for this project will be the pumps. This pumping equipment must be capable of transferring large volumes of water from a lower elevation to a higher elevation at low discharge pressures.

One pump manufacturer provides hydraulic drive axial flow pumps with capacities up to 50,000 gallons per minute (gpm). The equipment is very simple to operate, relatively easy to maintain and flexible. Drive units can be either mounted on tires for mobile operation or on skid mounts for installation on a pad. Skid mounted units will be required for this project in order to achieve the high discharge pressures required. Pumps of this type are well suited for this project.

## TABLE 9-1

## SUMMARY OF FACILITY DETAILS

| | |
|---|---|
| **DEEP HOLE CHANNEL** | |
| Length | 19,300 feet |
| Width at Bottom | 225 feet |
| Channel Invert Elevation | 53.0 feet MSL |
| Side Slopes | 15:1 |
| Cross Sectional Area (with water surface at 58.0 feet) | 1500 $ft^2$ |
| Design Flow | 717 $ft^3$/sec. |
| Average Velocity | 0.48 ft/sec. |
| Volume of Dredging Required | 1,310,000 $yd^3$ |
| **IN-LAKE SEDIMENTATION BASIN** | |
| Overall Length (inlet to outlet) | 6300 feet |
| Length of Rectangular Section | 3800 feet |
| Bottom Width | 1000 feet |
| Side Slope | 15:1 |
| Bottom Elevation | 48 feet MSL |
| Design Flow | 717 $ft^3$/sec. |
| Settling Velocity, $V_s$ | $2.88 \times 10^{-4}$ ft/sec. |
| Nominal Detention Time (rectangular portion only) | 16.7 hrs. |
| Surface Loading Rate (rectangular portion only) | 121 gpd/$ft^2$ |

## TABLE 9-1 (continued)

## SUMMARY OF FACILITY DETAILS

### IN-LAKE SEDIMENTATION BASIN (continued)

| | |
|---|---|
| Volume of Dredging Required | 3,480,000 $yd^3$ |
| Floating Turbidity Curtain (4 feet deep) | 1400 feet |
| Floating Vegetation Barrier | 400 feet |

### LAKE APOPKA PUMPING STATION

| | |
|---|---|
| Cofferdam length | 291 feet |
| Cofferdam width | 33.6 feet |
| Sump length | 100 feet |
| Sump width | 30 feet |
| Elevation of Bottom of Sump | 44.0 feet MSL |
| Sheet Pile Section | PZ-32 |
| Pump Type | Two stage, hydraulic drive, axial flow |
| Pump Size | 42-inch diameter discharge |
| Number of Pumps | 10 |
| Capacity | 40,000 gpm each |
| Drive Units | 460 hp skid mounted diesel engines |

### LAKE APOPKA WATER CONTROL STRUCTURE

| | |
|---|---|
| Broad Crested Weir Length | 101 feet |
| Sill Elevation | 64.0 feet MSL |
| H Pile | HP 10 x 24 |
| Channel | C 10 x 13.5 |
| Stop Logs | PT 6" x 8" |

## TABLE 9-1 (continued)

## SUMMARY OF FACILITY DETAILS

### APOPKA-BEAUCLAIR CANAL IMPROVEMENTS

| | |
|---|---|
| Length of Canal | 36,000 feet |
| Design Flow | 780 $ft^3$/sec. |
| Maximum Permissible Velocity | 2.5 ft/sec. |
| Minimum Required Cross Section | 312 $ft^2$ |

### APOPKA-BEAUCLAIR CANAL LOCK AND DAM PUMPING STATION

| | |
|---|---|
| Cofferdam Length | 135 feet |
| Cofferdam Width | 17.6 feet |
| Sump Length | 40 feet |
| Sump Width | 30 feet |
| Elevation of Bottom of Sump | 46 feet MSL |
| Pump Type | Two stage, hydraulic drive, axial flow |
| Pump Size | 42-inch diameter discharge |
| Number of Pumps | 5 |
| Capacity | 40,000 gpm |
| Drive Units | 460 hp skid mounted diesel engines |

### LAKE BEAUCLAIR PUMPING STATION

| | |
|---|---|
| Cofferdam Length | 149 feet |
| Cofferdam Width | 33.7 feet |
| Sump Length | 50 feet |
| Sump Width | 30 feet |

## TABLE 9-1 (continued)

## SUMMARY OF FACILITY DETAILS

### LAKE BEAUCLAIR PUMPING STATION (continued)

| | |
|---|---|
| Elevation of Bottom of Sump | 41 feet MSL |
| Pump Type | Two stage, hydraulic drive, axial flow |
| Pump Size | 42-inch diameter discharge |
| Number of Pumps | 5 |
| Capacity | 40,000 gpm each |
| Drive Units | 460 hp skid mounted diesel engines |

### LAKE BEAUCLAIR/LAKE CARLTON COFFERDAM

| | |
|---|---|
| Length | 80 feet |
| Type | Cantilever sheet pile wall |
| Sheet Pile Section | PZ-27 |

### LAKE BEAUCLAIR/LAKE DORA COFFERDAM

| | |
|---|---|
| Length | 500 feet |
| Type | Cantilever sheet pile wall |
| Sheet Pile Section | PZX-32, PZ-27 |

### LAKE DORA PUMPING STATION

| | |
|---|---|
| Length | 135 feet |
| Sump Length | 70 feet |
| Sump Width | 24 feet |
| Elevation of Bottom of Sump | 49 feet MSL |

## TABLE 9-1 (continued)

## SUMMARY OF FACILITY DETAILS

### LAKE DORA PUMPING STATION (continued)

| | |
|---|---|
| Sheet Pile Section | PDA-27, PS-28 |
| Pump Type | Two stage, hydraulic drive, axial flow |
| Pump Size | 30-inch diameter discharge |
| Number of Pumps | 7 |
| Capacity | 30,000 gpm |
| Drive units | 2 - 200 hp skid mounted electric motors |

### DORA CANAL BY-PASS PIPELINE

| | |
|---|---|
| Length | 7600 feet |
| Diameter | 84-inch |
| Wall Thickness | 7/16-inch |
| Material | Steel |
| Railroad Casing Pipe Diameter | 90-inch |
| Wall Thickness, Liner Plate | 0.164-inches |
| Wall Thickness, Multiplate | 0.138-inches |
| Operating Head | 22.5 feet |
| Operating Velocity | 8.44 ft/sec. |

### LAKE EUSTIS PUMPING STATION

| | |
|---|---|
| Length | 100 feet |
| Sump Length | 70 feet |
| Sump Width | 24 feet |
| Elevation of Bottom of Sump | 49 feet MSL |

## TABLE 9-1 (continued)

## SUMMARY OF FACILITY DETAILS

### LAKE EUSTIS PUMPING STATION (continued)

| | |
|---|---|
| Sheet Pile Section | PDA-27, PS-28 |
| Pump Type | Two stage, hydraulic drive, axial flow |
| Pump Size | 30-inch diameter discharge |
| Number of Pumps | 7 |
| Capacity | 30,000 gpm |
| Drive Units | 2 - 200 hp skid mounted electric motors |

### DEAD RIVER DAM AND BOAT LIFT

| | |
|---|---|
| Length | 507 feet |
| Length of Weir | 135 feet |
| Cofferdam Type | Cantilever Sheet Pile Wall |
| Sheet Pile Sections | PZX32, PZ38, PZ27 |
| H Pile | HP 10 x 57, HP 12 x 53, HP 14 x 73 |
| Stop Logs | PT 6" x 8" |

### B. Control Stations

The central control station will be established at the Apopka-Beauclair Canal Lock and Dam. The central control station will serve as the project headquarters during the entire project, directing and coordinating the construction and operation of all facilities. This site is centrally located and easily accessible. Telephone and electricity are readily available.

In addition, a citrus irrigation control station will be established in the Winter Garden area. This station will direct and coordinate the mobile irrigation equipment and irrigation wells.

### C. Communication System

During the course of the entire project, communication between the various sites will be very important. Telephones will be installed at the sites where telephone service is readily available. Remote sites (those which are not readily accessible by telephone service) will be linked to the central control station by two-way radio.

### D. Protection of Property

Protecting people and animals from dangerous areas at several sites as well as preventing vandalism are also considerations on a project of this magnitude. Temporary fences are required at the sites accessible to the general public in order to keep them away from equipment and excavations. Vandalism should not be as serious a concern considering that each site will require full time supervision. These areas will be posted to make the public aware of danger.

During certain phases of the project, considerable flow will be conveyed by the canals interconnecting the lakes downstream from Lake Apopka. The velocities created by these conditions may make it difficult or impossible to operate boats in the canals, especially in the narrower areas. Therefore, these areas will require more intensified boat patrols to restrict boat traffic when conditions are dangerous and to handle emergencies. Posting of the various waterways to warn boaters of danger will also be necessary.

## 9.02 LAKE APOPKA DEEP HOLE CHANNEL

The proposed method for draining Lake Apopka to 58 feet MSL includes hydraulic dredging of a trapezoidal channel which will connect "deep hole" areas in the lake and convey water to the intake sump of the main pump station at the south end of the Apopka-Beauclair Canal. Based on a maximum velocity of flow in the dredged channel of 0.5 feet per second (fps) to prevent entrainment of any surrounding muck material, and an average volumetric flow rate of 500 MGD, the channel will be cut to 53 feet MSL, 225 feet wide at the base, and have side slopes of about 15:1. The main channel will be four miles long. The route of the deep hole channel is shown in Figure 9-1. An estimated 1.3 million cubic yards of material will have to be dredged in constructing the channel. For more information about the deep hole channel, see Table 9-1 and the Drawings and Specifications.

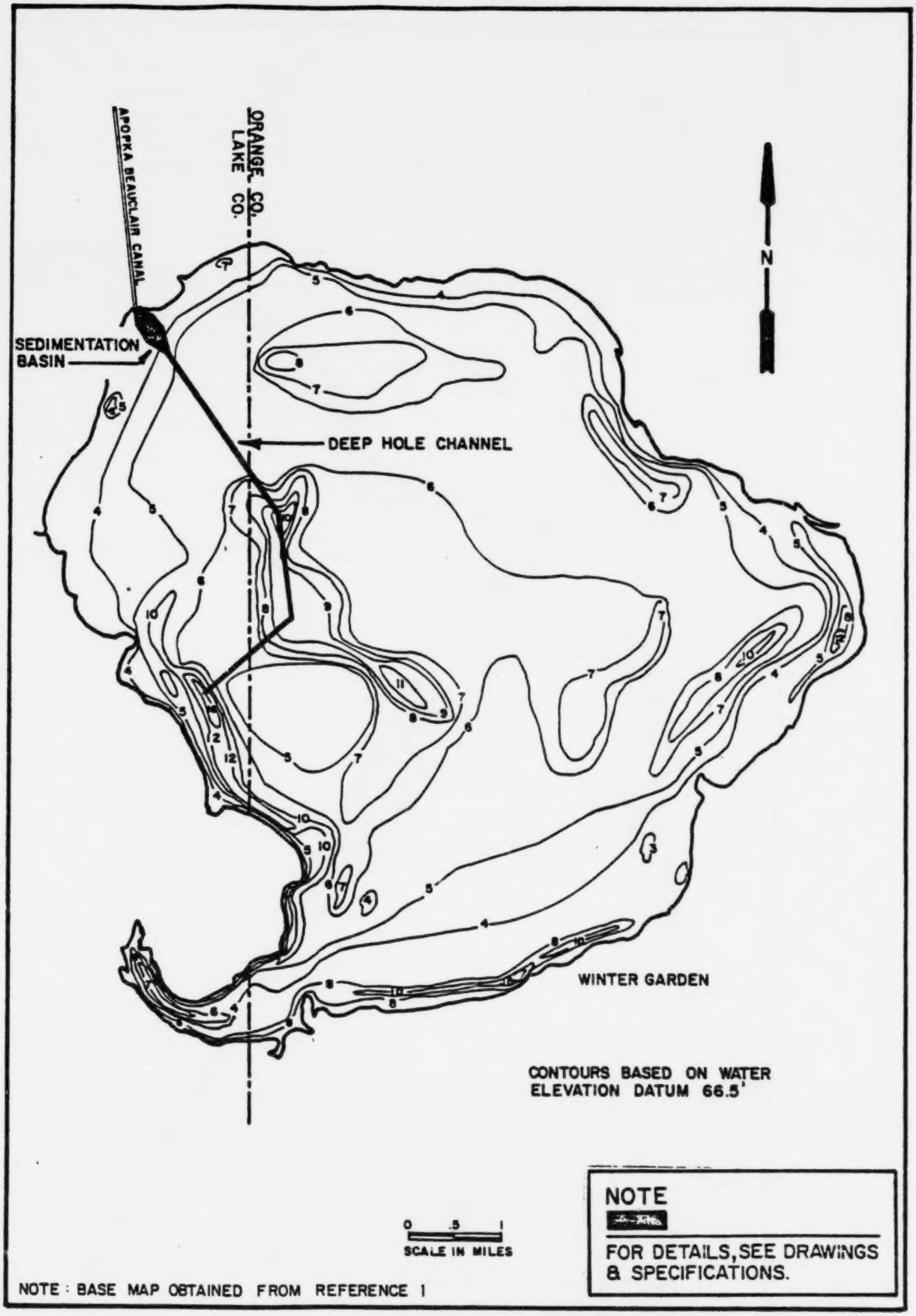
Channel excavation will involve the use of floating hydraulic dredges equipped with augers and pumps to discharge material back into the lake as far away as practical by a floating discharge pipe. This excavated material will settle to the bottom of the lake and receive the same consolidation treatment as the rest of the lake bottom during drawdown and holddown.

## 9.03 IN-LAKE SEDIMENTATION BASIN

In order to protect downstream water quality, an in-lake sedimentation basin will be used to remove sediment from the Lake Apopka water before it is pumped from Lake Apopka and discharged into the Apopka-Beauclair Canal. Location of the in-lake sedimentation basin is shown in Figure 9-2. The sedimentation basin will be approximately 6300 feet long and 1000 feet wide at its widest point. See Table 9-1 and the Drawings and Specifications for more information.

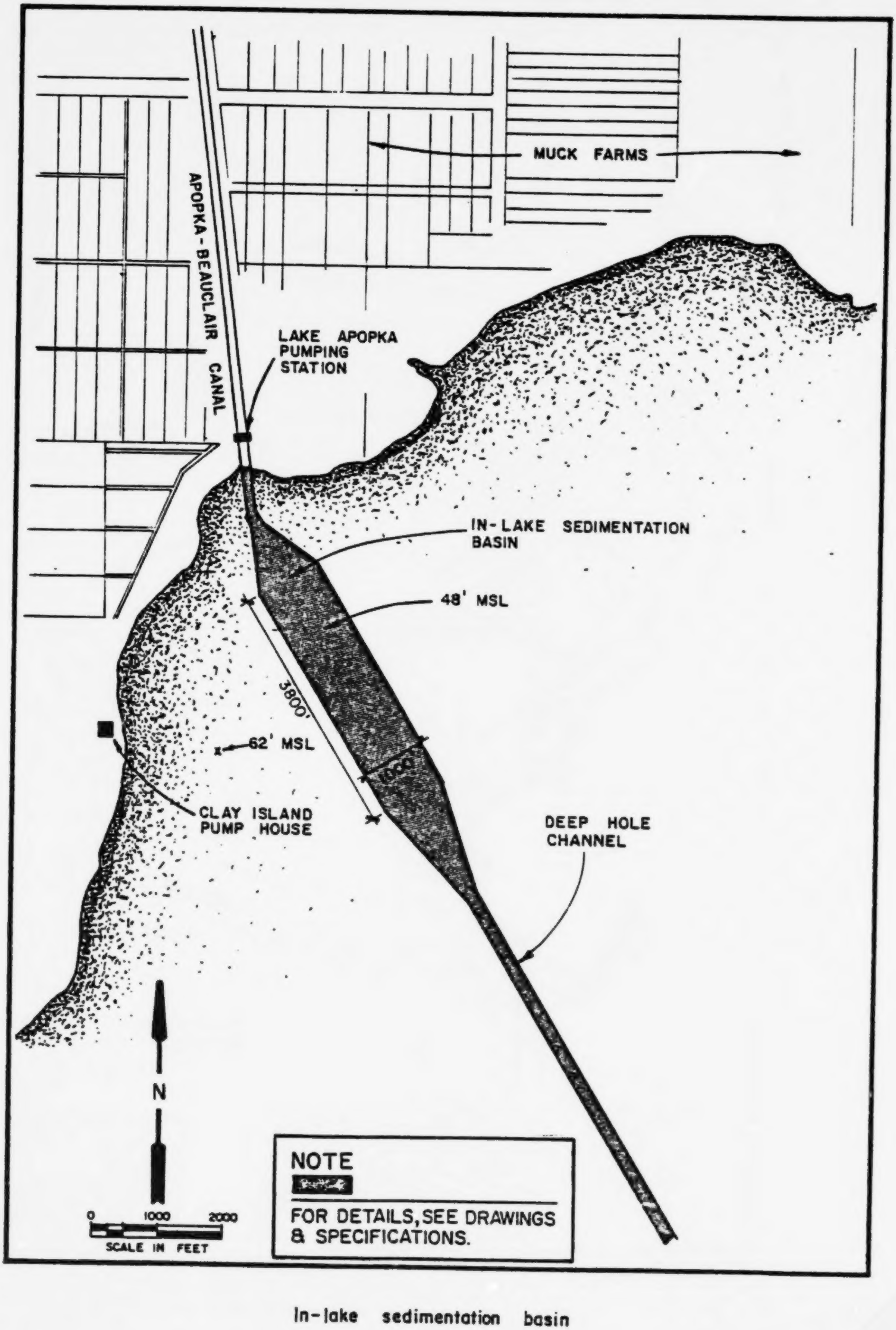
The sedimentation basin will be dredged to a bottom elevation of approximately 48 feet MSL (about 13 feet below the existing bottom elevation) with 15:1 side slopes. A typical cross section at the widest part of the basin is shown in Figure 9-3. The basin will be dredged by a floating hydraulic dredge; dredged muck and clay will be disposed of laterally away from the basin by floating discharge lines. The sand encountered during the last 4.5 feet of dredging will be discharged relatively near the basin. This will result in a firmer crust after consolidation and aid in the operation of the sedimentation basin during the end of the drawdown phase and during the holddown phase. In addition, a portion of sand will be spoiled just east of the Lake Apopka Pumping Station site to be used later for access road improvements and dike improvements.

The basin will provide an average detention time of 16.7 hours, and a surface loading rate of 121 gallons/day/ft$^2$. This surface loading rate is lower than suggested in Section 7, to provide a buffer against any unforeseen problems which might arise with basin operation or influent water quality. This higher detention time and lower surface loading rate also avoids the need to utilize chemicals to aid sedimentation, thereby minimizing operation costs.


APOPKA BEAUCLAIR CANAL
ORANGE CO.
LAKE CO.
N
SEDIMENTATION BASIN
DEEP HOLE CHANNEL
WINTER GARDEN
CONTOURS BASED ON WATER ELEVATION DATUM 66.5'
0 .5 1
SCALE IN MILES
NOTE
FOR DETAILS, SEE DRAWINGS & SPECIFICATIONS.
NOTE : BASE MAP OBTAINED FROM REFERENCE 1

Location of deep hole channel and in-lake sedimentation basin

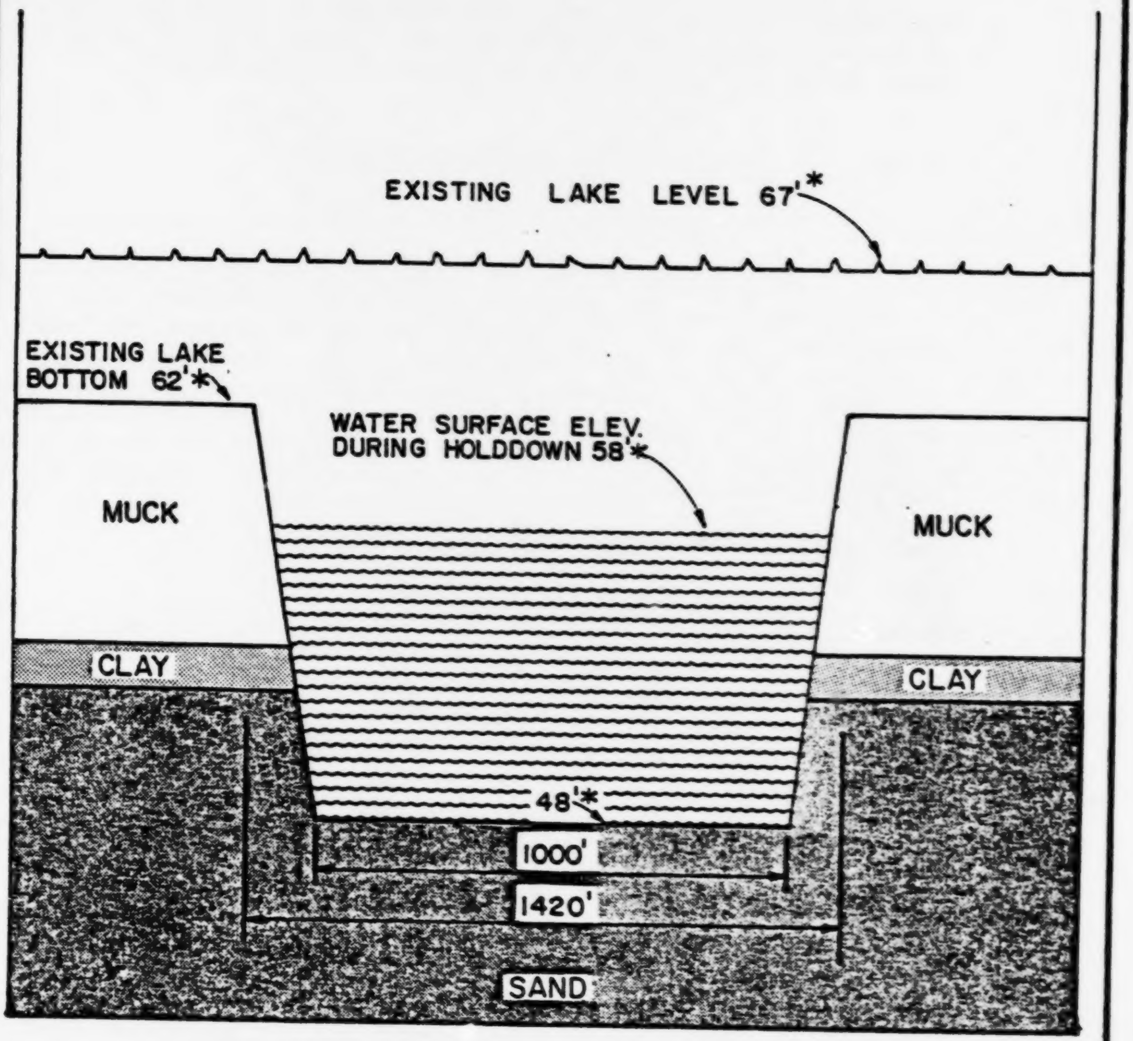
FIGURE 9-1


MUCK FARMS
APOPKA-BEAUCLAIR CANAL
LAKE APOPKA PUMPING STATION
IN-LAKE SEDIMENTATION BASIN
48' MSL
3800'
1000'
62' MSL
CLAY ISLAND PUMP HOUSE
DEEP HOLE CHANNEL
N
0
1000
2000
SCALE IN FEET
NOTE
FOR DETAILS, SEE DRAWINGS & SPECIFICATIONS.

In-lake sedimentation basin

NOTE
[redacted]

FOR DETAILS, SEE DRAWINGS & SPECIFICATIONS.


EXISTING LAKE LEVEL 67'*
EXISTING LAKE BOTTOM 62'*
WATER SURFACE ELEV. DURING HOLDDOWN 58'*
MUCK
MUCK
CLAY
CLAY
48'*
1000'
1420'
SAND

NOTE,

SOIL INFORMATION SHOWN IS FOR ILLUSTRATIVE PURPOSES ONLY AND MAY NOT REPRESENT CONSTRUCTION CONDITIONS.

* ELEVATIONS IN FEET ABOVE M.S.L.

Typical cross section of the in-lake sedimentation basin

FIGURE 9-3

The sedimentation basin will remain submerged until the Lake Apopka water surface is lowered below 62 feet MSL. At that time, the sedimentation basin will appear. When the water level approaches 58 feet MSL, there will be four feet of freeboard, thereby minimizing wind effects and agitation during the period when the worst influent water quality is expected.

Settled solids which accumulate in the bottom of the sedimentation basin will be removed by floating hydraulic dredges operating in the basin. These solids will be discharged away from the basin and allowed to consolidate.

## 9.04 LAKE APOPKA PUMPING STATION

### A. General

The first of the two drawdown/holddown pumping facilities will be located on the Apopka-Beauclair Canal, approximately 600 feet north of the entrance to Lake Apopka. A cofferdam will be built across the Apopka-Beauclair Canal to support the necessary pumping equipment. Water will be pumped out of the intake sump on the Lake Apopka side of the cofferdam, lifted over the cofferdam and discharged into the Apopka-Beauclair Canal. The Lake Apopka pumping station is shown in Figure 9-4. For specific design details, see Table 9-1 and the Drawings and Specifications.

### B. Approach Channel

In order to accommodate the large flows to the pump station, the Apopka-Beauclair Canal will require dredging to 50 feet MSL for a distance of approximately 1000 feet from the sedimentation basin to the intake sump at the pumping station. The existing canal bottom is approximately 60 feet MSL so that about 111,000 cubic yards of material will need to be dredged along the 130 foot width of the canal. Disposal of the dredged material will be via long floating discharge conduits into Lake Apopka away from the deep hole canal area.

### C. Sump and Protective Barriers

For the pumps to function properly over the range of lake levels which will occur during drawdown and holddown, an adequate water depth must be maintained over the pump inlet. Therefore, a sump must be excavated to 44.0 feet MSL. To provide adequate space for ten inlet pipes, this sump must be 30 feet wide and 100 feet long. The bottom of the sump will be lined with riprap to prevent scouring of bottom sediments.

Upstream of the sump will be a wildlife net to keep alligators, turtles, etc. from entering the sump and intake pipes. A vegetation barrier will be located upstream of the wildlife net to keep hyacinths and other floating plants away from the pumps. This barrier will be supported by pipe piles driven into the canal bottom. The wildlife net will extend to the bottom of the canal whereas the vegetation barrier should only reach about 2 feet below the water surface. For details concerning sump and protective barriers, refer to the Drawings and Specifications.

### D. Cofferdam

At the end of the holddown period, the water level in Lake Apopka will be at 58 feet MSL. The existing ground near the pump station site is approximately 69 feet MSL. A cofferdam will be built across the width of the canal and tie into the existing berm along both banks. The top of the cofferdam will be at 70.5 feet MSL. The width of the cofferdam will be at least 30 feet in order to provide sufficient space for pumps, discharge pipes, and vehicle access. An estimated 5600 cubic yards of fill material will be required to build the dam. For details, refer to Table 9-1 and the Drawings and Specifications.

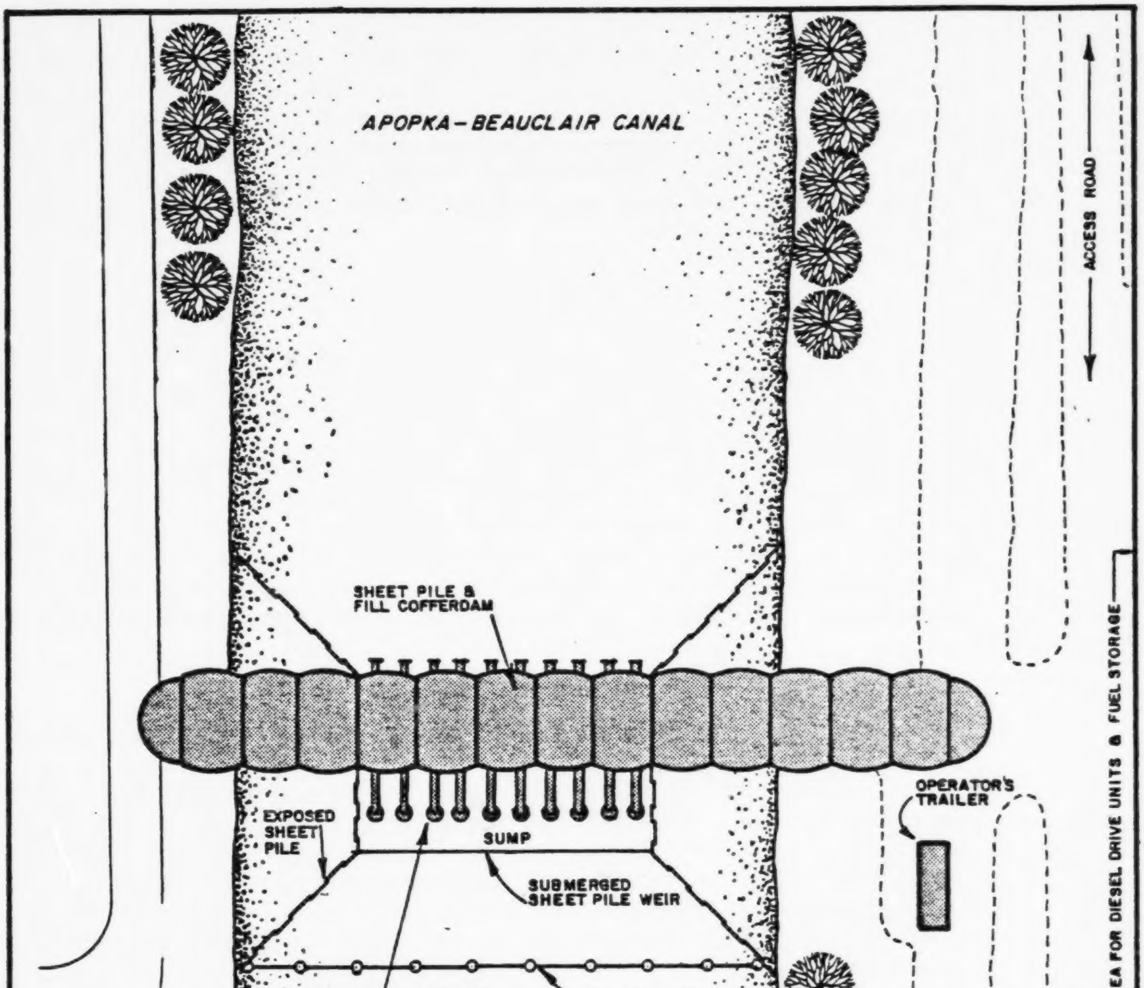
### E. Access

A private farm road along the east side of the canal will be used for access to this site. The road must be upgraded to handle heavier and wider construction vehicles. Upgrading will consist of widening the road to 24 feet, providing parking, a turn-around at the site, and adding sand or other suitable fill material to wet areas and low spots. At the conclusion of the project, the road could either be restored to its original condition or remain as modified at the owner's discretion.

### F. Pump Units

The pumps are designed to function during the drawdown and holddown periods. The worst design condition occurs at the end of the drawdown period when water is being pumped at a rate of 500 MGD from an elevation of 58 feet MSL to an elevation of 68.5 feet MSL on the north side of the cofferdam.

To deliver 500 MGD against a total dynamic head of 12.5 feet, double staging of pumps will be required. A total of ten 430 HP diesel drive units will be required to drive the double staged hydraulically powered axial flow pumps. Under normal operating conditions only eight of the pumps will be in operation, with the remaining two pumps and two diesel drive units serving as stand-by units. The 430 HP diesel drive units which supply pressure to the hydraulically driven axial flow pumps will be mounted on skids and located away from the dikes to minimize settlement in the immediate vicinity of the dike. For details on the location of the diesel units, see the Drawings and Specifications.


APOPKA-BEAUCLAIR CANAL
ACCESS ROAD
SHEET PILE & FILL COFFERDAM
EXPOSED SHEET PILE
SUMP
SUBMERGED SHEET PILE WEIR
OPERATOR'S TRAILER
IMPROVED AREA FOR DIESEL DRIVE UNITS & FUEL STORAGE
HYDRAULICALLY DRIVEN 42" AXIAL FLOW PUMPS
WILDLIFE NET
FLOW
N
NOTE
▨
FOR DETAILS, SEE DRAWINGS & SPECIFICATIONS.

Lake Apopka pumping station.

FIGURE

The pumps will take suction from the sump and discharge flow directly into the Apopka-Beauclair Canal north of the cofferdam. All pump discharge pipes will cross under the access road and discharge into the Apopka-Beauclair Canal.

### G. Control Trailer

A mobile trailer will be installed at the site to provide housing for the operators. The trailer will also provide housing for radio equipment, records, maintenance tools, etc.

### H. Fuel Storage

Two 10,000-gallon fuel storage tanks will be required at the cofferdam to supply the diesel pumps with fuel. It is estimated, that, with the pumps running on a 24-hour basis, the fuel tanks will need to be refilled once every week by tank truck deliveries.

### I. Refill Modifications

Prior to refill, the Lake Apopka pumping station will be modified to become the Lake Apopka water control structure. This water control structure will allow the water level in the Apopka-Beauclair Canal to be regulated to provide sufficient head for muck farm irrigation.

Modifications will consist of removing all pumps, etc. from the cofferdam and lowering a 100-foot segment of the dam to 64 feet MSL. H-piles, channels, stop logs and riprap will be installed on top of this segment to create an adjustable stop-log weir. Water will flow over this weir, across the remaining portion of the cofferdam and cascade into the former sump (now an effective energy dissipater). Stop-logs can be added or removed as necessary to modify the water surface elevation of the Apopka-Beauclair Canal. For details, see the Drawings and Specifications.

## 9.05 APOPKA-BEAUCLAIR CANAL

### A. Silt Removal

While the velocities in the Apopka-Beauclair Canal during drawdown will not erode the protected or unprotected areas of the adjacent dikes, they may be sufficient to convey silt from the existing canal bottom and deposit it in Lake Beauclair. The field survey indicates that deposits of transportable silt are located in several reaches of the Apopka-Beauclair Canal.

Dredging the canal in these areas will be required, to remove the silt and prevent its movement into Lake Beauclair. A hydraulic dredge or dragline will be utilized to remove the silt, and discharge it onto the side slopes of the dike away from the canal. The method of excavation will be the contractors decision; the method of disposal will be dictated by land conditions in the given reach of the canal. For more information, see the Drawings and Specifications.

### B. Dike Protection

During the drawdown phase when the maximum quantity of water is pumped from Lake Apopka to the downstream side of the cofferdam in the Apopka-Beauclair Canal, a maximum water surface below the cofferdam of 68 feet MSL can be expected. Existing dike elevations from the Lock and Dam to Lake Apopka vary between 65 feet MSL and 70 feet MSL. Therefore, protection of the dikes will be required in this area to provide a minimum freeboard of two feet. The dike elevation would be brought up to 70 feet MSL at Lake Apopka and to 69 feet MSL upstream of the Lock and Dam. Existing dike elevations in the immediate vicinity of the Lock and Dam are primarily above 70 feet MSL. However, some areas vary around 68 feet MSL. Fill material used to raise dike elevations will be locally available coarse sand.

Maximum water surface elevations below the Lock and Dam during the various phases have been previously discussed in Section 5. Existing dike elevations in this area vary from 70 feet MSL to 65 feet MSL. Only scattered areas will require improvement. For details regarding these improvements, see the Drawings and Specifications.

In the area immediately upstream and downstream of the Lock and Dam considerable turbulence will be created by the water cascading over the dam during the drawdown, holddown, and refill phases. Dike and canal bottom protection will be required in these areas to prevent scouring action created by the turbulent water. The method which will be employed is to use bagged concrete and/or bagged sand, rubble or sheet pile, to line the channel in the immediate vicinity of the Lock and Dam. This riprap will be removed after the refill phase. There are four bridges over the Apopka-Beauclair Canal, i.e. two highway, one farm and one railroad type. They are primarily supported by wooden piles. The maximum velocity which will be created in the canal during the project is not expected to exceed about 2 fps, although there may be locally higher velocities in the vicinity of the bridge piles. Riprap will be placed to protect the bridge piles. For details, see the Drawings and Specifications.

## 9.06 DORA CANAL

During the drawdown and holddown phases, pump facilities will be required at the entrance of the Dora Canal from Lake Dora. Since the canal has limited capacity to transmit flow, a portion of the water will be pumped into an 84-inch diameter by-pass pipeline and transmitted to Lake Eustis. The Dora Canal facilities are shown in Figure 9-5.

During the refill phase, the pumps will be relocated to Lake Eustis refill pumping station and the process reversed. Again, due to the hydraulic limitations of Dora Canal, a portion of the refill water will be back pumped into the 84-inch diameter pipeline and transmitted to Lake Dora.

### A. Lake Dora Drawdown Pumping Station

#### 1. Inlet Sump

A sump will be excavated at the shoreline 25 feet wide and 70 feet long to house the seven pump suctions and to provide for adequate water storage during pumping operation (see Figure 9-6). For details, see Table 9-1 and the Drawings and Specifications.

Sheeting will be driven around the proposed sump to create a box. The top of the sheeting will be at about 57.5 feet MSL to form a weir which will allow water to spill into the sump during the pumped drawdown and holddown phases, preventing bottom deposits from entering the sump. During the refill phase the weir will prevent excessive scouring of the lake bottom in the immediate vicinity of the by-pass pipe by allowing the energy to dissipate within the confines of the sump.

The sump will be excavated to an elevation of approximately 49 feet MSL, or about eight feet below the existing adjacent lake bottom. Large riprap will be placed in the bottom of the sump to prevent erosion of the bottom. Similarly, riprap will be required outside the sump adjacent to the sheeting to prevent scouring. A vegetation barrier will be installed immediately upstream of the sump, as well as a wildlife net to prevent floating vegetation, fish and alligators from entering the sump.

#### 2. Pump Units

Six electric drive 30-inch axial flow pumps, and one stand-by pump, will be required at the site for the pumped drawdown and holddown phases. The total capacity of the station is designed to pump 156,000 gpm against a total dynamic head of 25 feet. For more information, refer to Table 9-1 and the Drawings and Specifications.

The pumps will take suction from the sump and discharge the flow to a common discharge manifold. The manifold would in turn feed into an 84-inch diameter steel transmission by-pass line to Lake Eustis. Provision will be made to monitor the water being pumped by installation of a sample tap on the discharge manifold.

A transformer substation will be required at the site to reduce line voltage for the fourteen, 200 HP electric motors. The use of electric motors in this populated area should keep noise levels below an objectionable threshold value.

Pumps will be operated manually at sufficient rates to convey adequate quantities of water during pumped drawdown and holddown phases from Lake Dora to Lake Eustis without raising the level of Lake Dora above 64 feet MSL and thus preventing flooding both in Lake Dora and in the Dora Canal. The water depth in Lake Dora will be obtained from a gage and the information relayed periodically to the central control station for overall operation control. An alarm system will also be installed which will be activated if the water level rises above a preset value.

### 3. Control Trailer

A mobile trailer will be installed at the site to provide housing for the operators. The trailer will also provide housing for radio equipment, records, maintenance tools, etc.

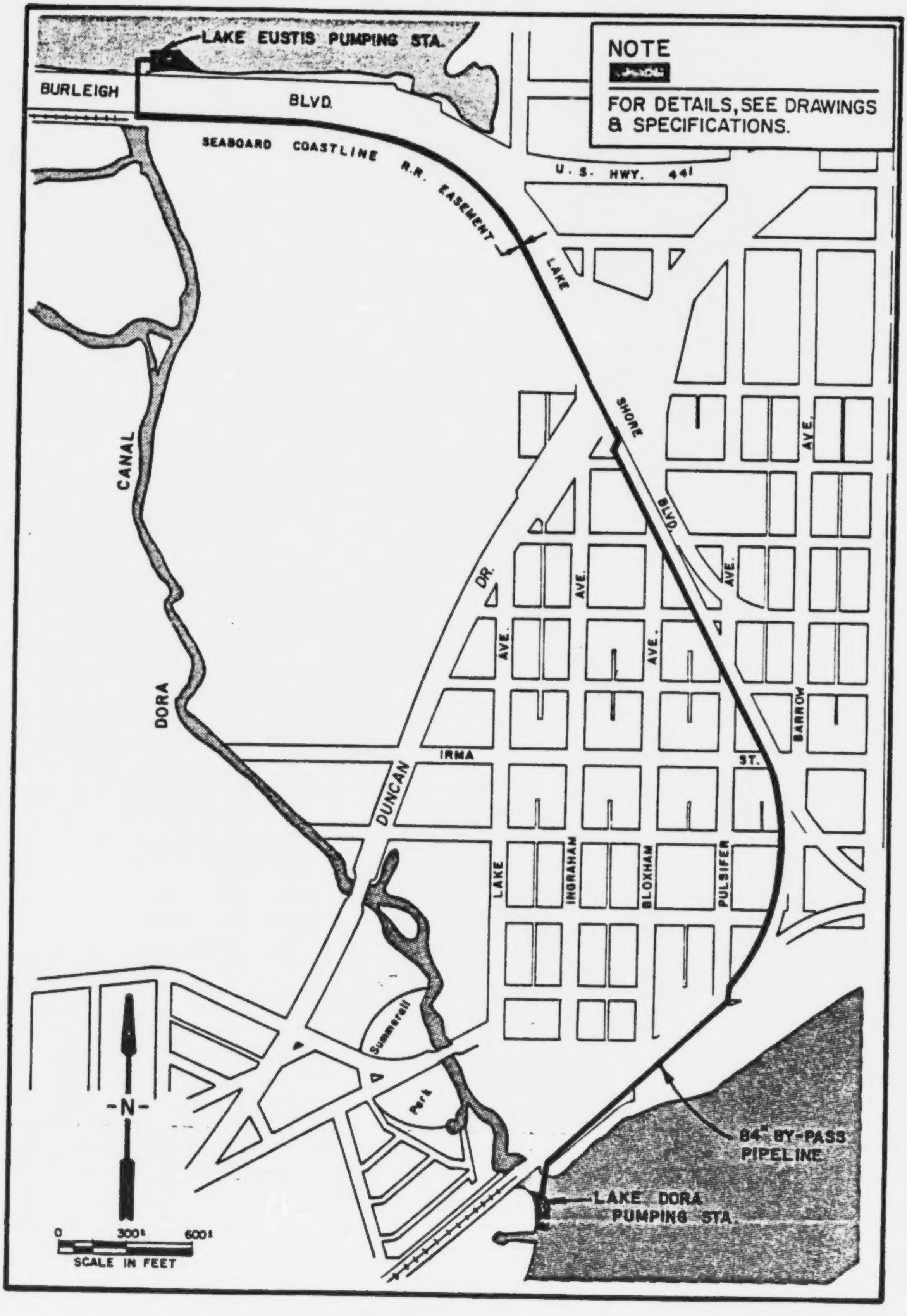
### 4. Access Road

Access to the site will be over a road which will be constructed by extending the existing road now serving residences to the southwest of the pump station site. Some trees will require removal for construction of the road and other facilities at the site. A coarse sand road of sufficient capacity to handle heavy vehicles will be adequate, and will be removed at the completion of the project.

## B. Transmission By-Pass Line

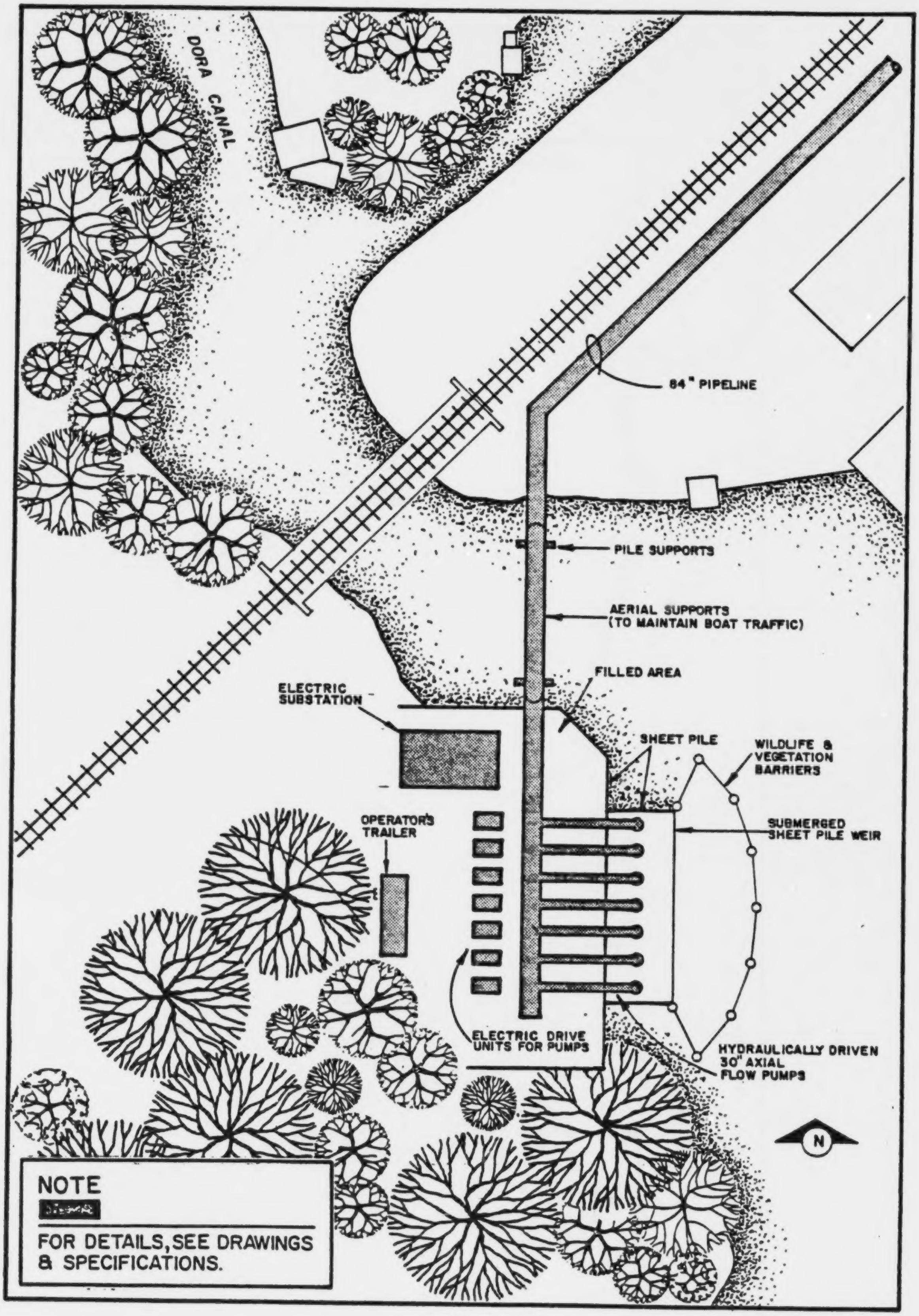
A by-pass pipeline will be required to convey flow from the Lake Dora pumping station to Lake Eustis during drawdown and holddown phases of operation, and to convey flow from the Lake Eustis pumping station to Lake Dora during the refill phase. The maximum flow of water to be by-passed is estimated to be about 325 cubic feet per second (cfs). Flow of this magnitude will require the use of 84-inch diameter, 7/16-inch thick walled steel pipe.

As shown on Figure 9-5, the pipe will proceed from the Lake Dora pumping station site, up and over the Dora Canal (thereby maintaining boat traffic during the project)


LAKE EUSTIS PUMPING STA.
NOTE
FOR DETAILS, SEE DRAWINGS & SPECIFICATIONS.
BURLEIGH
BLVD.
SEABOARD COASTLINE R.R. EASEMENT
U.S. HWY. 441
LAKE
SHORE
BLVD.
CANAL
DORA
DUNCAN
DR.
IRMA
ST.
AVE.
AVE.
AVE.
AVE.
AVE.
BARROW
LAKE
INGRAHAM
BLOXHAM
PULSIFER
Summerall
Park
N
0
300'
600'
SCALE IN FEET
84" BY-PASS PIPELINE
LAKE DORA PUMPING STA.

Dora canal facilities

FIGURE 9-5


DORA CANAL
84" PIPELINE
PILE SUPPORTS
AERIAL SUPPORTS
(TO MAINTAIN BOAT TRAFFIC)
FILLED AREA
ELECTRIC SUBSTATION
SHEET PILE
WILDLIFE & VEGETATION BARRIERS
SUBMERGED SHEET PILE WEIR
OPERATOR'S TRAILER
ELECTRIC DRIVE UNITS FOR PUMPS
HYDRAULICALLY DRIVEN 30" AXIAL FLOW PUMPS
N
NOTE
[redacted]
FOR DETAILS, SEE DRAWINGS & SPECIFICATIONS.

Lake Dora pumping station

FIGURE 9

and then south along the railroad track of the railroad right-of-way about 1200 feet from the Dora Canal, the pipe will cross under the track and then proceed along the west side of the railroad right-of-way to Irma Street in Tavares. At this location the pipe will be installed in an excavated trench under the street. Utilities in the street will be avoided where possible.

After crossing Irma Street, the pipe will proceed along the railroad right-of-way toward State Road 19. About 150 feet south of S.R. 19, the pipe will again cross under the railroad tracks and then cross under S.R. 19. North of S.R. 19, a railroad spur track will be removed and the pipe laid in its place. When the project is completed and the pipe removed, the railroad spur track will be restored. At the north end of the Dora Canal, the pipe will cross under the U.S. Highway 441 bridge and end at the Lake Eustis pumping station site, utilizing the sump for energy dissipation. Total length of the pipeline is approximately 7300 feet. For specific details on the pipeline location, see the Drawings and Specifications.

Most of the by-pass pipeline route will be accessible by a temporary road to be constructed along side the pipe. In some areas, however, this will not be required or even feasible. Installation of pipeline can be accommodated by working from the existing railroad embankment, north of the Seaboard Coast Line Railroad along the spur which goes through Tavares, used only for the storage of railroad cars. Along the last 2000 feet of the pipeline approaching Lake Eustis, the pipeline can be accessed from the railroad and the Department of Transportation right-of-ways. For details, see the Drawings and Specifications. On termination of the project, the pipe will be removed and the project area restored to its original condition.

The elevation of the pipe at either end (Lake Eustis or Lake Dora) will be approximately 60 feet MSL. The high points of the pipe will occur at the Dora Canal crossing near the Lake Dora pumping station and between S.R. 19 and Irma Street. Because it will be a pressure pipe over its entire route, lateral support will be required, especially at changes of direction, to prevent the pipe joints from pulling apart. Lateral protection for the straight alignment sections is proposed by installing the pipe in a trench excavated up to mid-diameter of the pipe. Where there are abrupt changes in direction the pipe will be securely restrained by concrete thrust blocks. All joints will be the bell and weld type. Sensors will be installed to detect any breaks which might occur. In the event of a break, an alarm will sound and the pumps will be immediately shut down.

## C. Lake Eustis Pumping Station

### 1. Inlet Sump

The energy dissipater constructed at the refill pump station site near Lake Eustis will be converted to a sump for the refill pumps (see Figure 9-7). The seven discharge pipes will be removed from the 84-inch manifold and relocated at the Lake Dora pumping station. No additional work will be required to convert the energy dissipater to a sump as it will be constructed initially to be used for the dual purposes. The features of the structure will be identical to the sump described earlier for the pumped drawdown and holddown phases. Vegetation and wildlife barriers will also be installed around the weir and sump.

### 2. Pump Units

The seven electric drive 30-inch axial flow pumps from the Lake Dora pumping station will be transferred to this site and installed. Each pump will take suction from the sump and discharge its contents to the discharge manifold and 84-inch transmission by-pass line. The flow will be discharged into the sump at the Lake Dora pumping station which will be used as an energy dissipator during refill.

Provisions will be made for obtaining a sample of water being pumped in order to monitor the quality of water returning to Lake Dora.

Adequate electric service can be extended to provide power at this location for the pumps. A transformer substation will be required at the site to reduce line voltage for the fourteen, 200 HP electric motors.

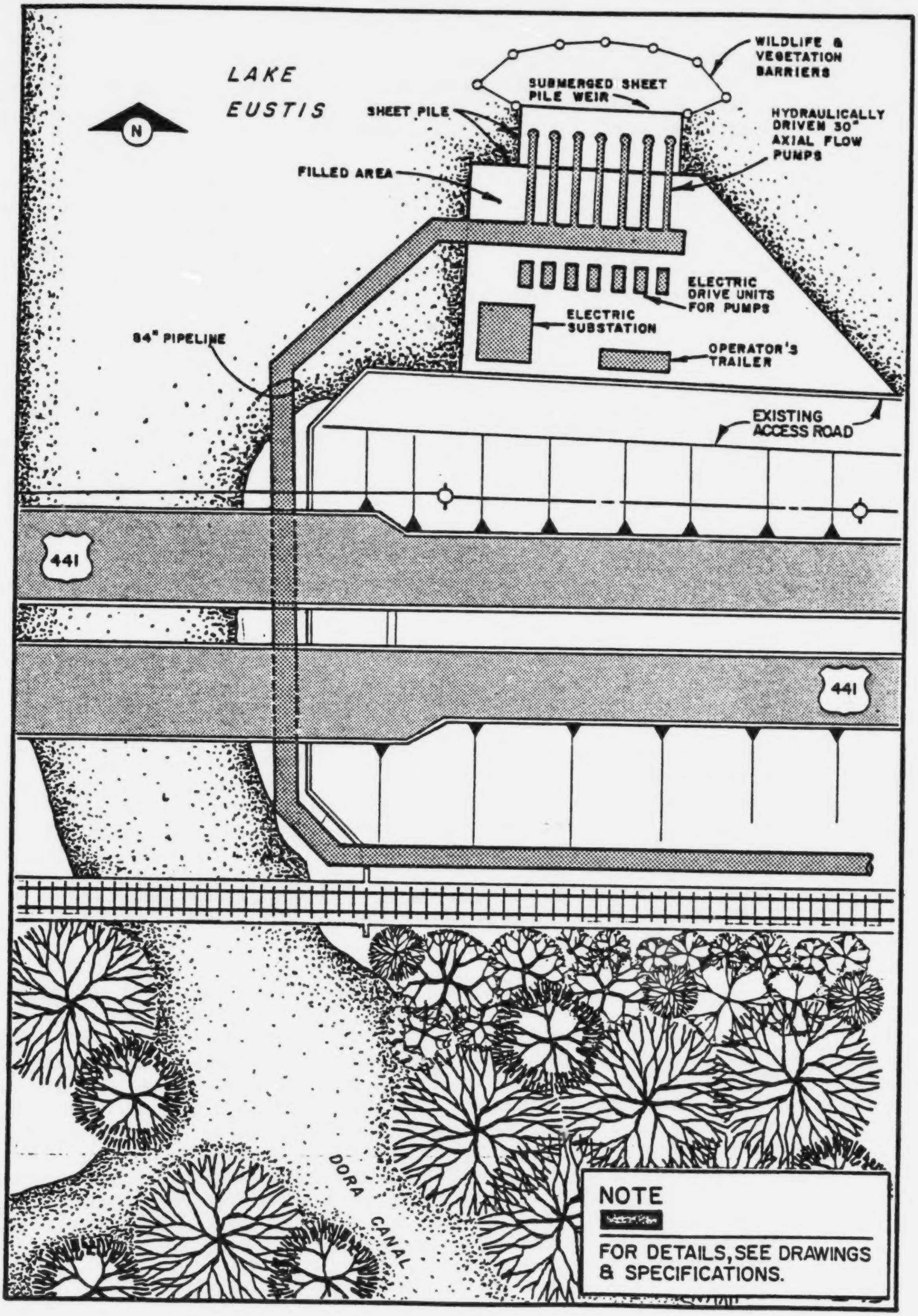
Pumps will be controlled manually by the operator according to information received from the central control station located at the Apopka-Beauclair Canal Lock and Dam. The water level in Lake Eustis will be monitored by a water level gage each day and the information transmitted to the central control station.

### 3. Control Trailer

A mobile trailer will be installed on the site to provide housing for the operator. The trailer will also provide housing for radio equipment, records, maintenance tools, etc.

### 4. Access Road and Miscellaneous Site Work

An access road presently exists from U.S. Highway 441 to the site. This paved road is adequate for trucking


LAKE EUSTIS
N
WILDLIFE & VEGETATION BARRIERS
SUBMERGED SHEET PILE WEIR
SHEET PILE
HYDRAULICALLY DRIVEN 30" AXIAL FLOW PUMPS
FILLED AREA
ELECTRIC DRIVE UNITS FOR PUMPS
ELECTRIC SUBSTATION
84" PIPELINE
OPERATOR'S TRAILER
EXISTING ACCESS ROAD
441
441
DORA CANAL

NOTE
▨
FOR DETAILS, SEE DRAWINGS & SPECIFICATIONS.

Lake Eustis pumping station

FIGURE 9 - 7

operations during construction and operation phases. A turn around area will be provided where space permits off the access road. After completion of the project, this access road will be restored to its original condition.

Presently, there is not enough land at the site to hold all of the facilities required. Additional land will be provided by sheeting a short distance into the lake and filling in behind the sheeting. For details, see the Drawings and Specifications. After termination of the project, the area will be completely restored to its original condition.

### D. Protection in the Dora Canal

There are two railroad bridges and two highway bridges over the Dora Canal. During the drawdown, holddown, and refill phases higher than normal velocities will occur in the canal. While the bridges do appear to have, in general, adequate riprap protection of the abutments, the piling supports may require some protection to minimize scouring of material around the piles. This will be accomplished by sheeting or sand bagging. For details concerning riprap protection, see the Drawings and Specifications.

## 9.07 DEAD RIVER

### A. Cofferdam and Flow Control

During the pumped drawdown and holddown phases of the project, backflow from Lake Eustis to Lake Harris will be prevented by the construction of a cofferdam (shown in Figure 9-8) across the Dead River immediately north of the U.S. Highway 441 bridge. This dam will also allow the filling of Lake Harris to provide storage water for the refill of Lake Apopka. The cofferdam will span approximately 530 feet and will be constructed with a single row of sheeting rising to an elevation of 65.0 feet MSL. For details, see Table 9-1 and the Drawings and Specifications.

In order to prevent Lake Harris from exceeding its maximum operating level of 63.5 feet MSL, a flow control device in the form of a 135 foot long weir with removable stop logs will be constructed in the cofferdam. During the pumped drawdown and holddown phases, the weir will be set at an elevation of 64 feet MSL to prevent water from backing up the Dead River and entering Lake Harris, especially near the end of the holddown phase when Lake Eustis will be at its maximum water surface elevation of 63.5 feet MSL. The stop logs can be removed in the weir as required during this period to prevent Lake Harris from exceeding 63.5 feet MSL. During the refill period, the adjustable weir will be used to control the rate of flow from Lake Harris to Lake Eustis.

## B. Boat Lifting Facility

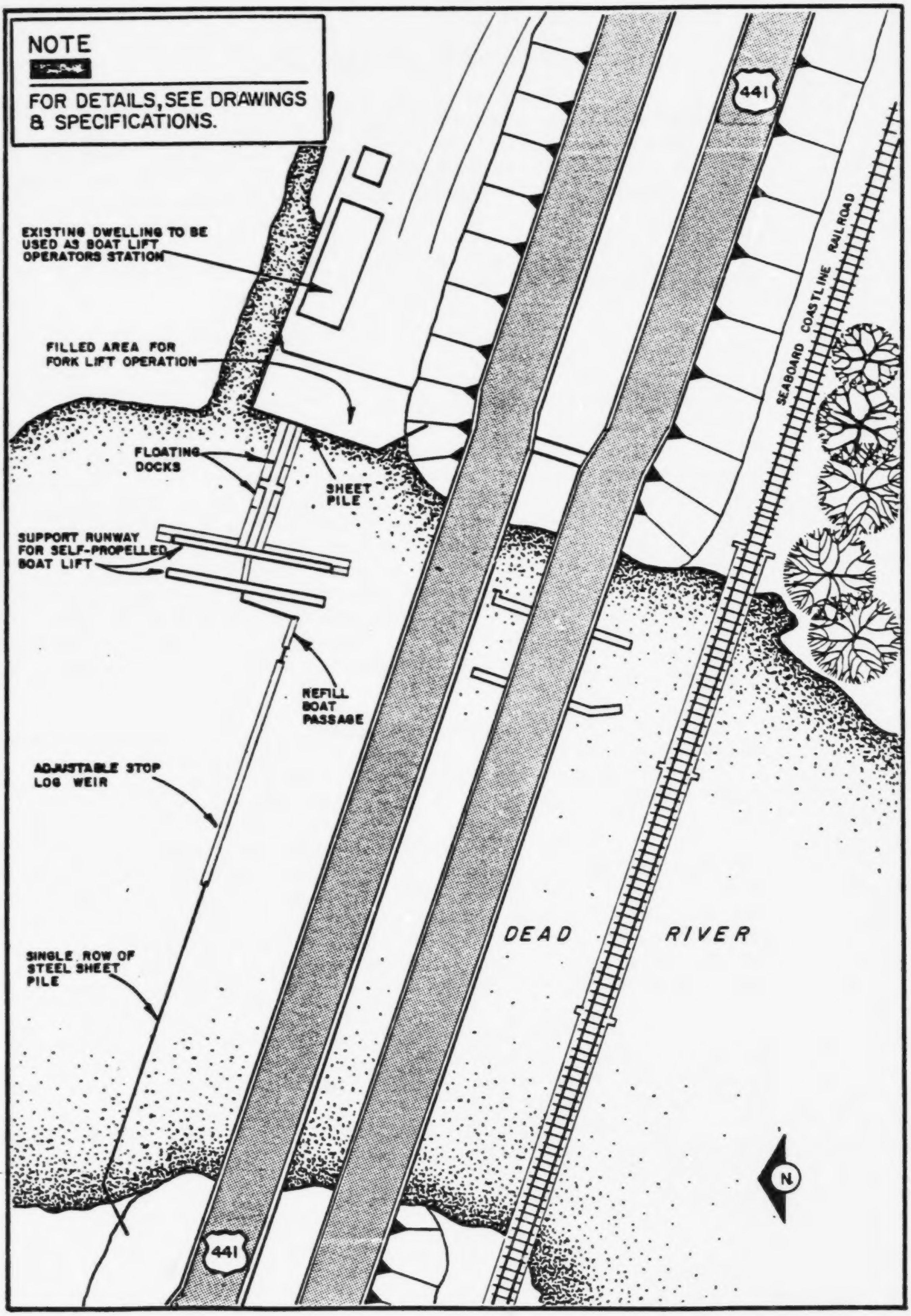
Boat traffic in the Dead River which must cross the dam will be accommodated by a boat lift. Most of the boats that travel through the Dead River are less than 20 feet in length; however, houseboats of up to 40 feet in length have been observed. To accommodate the number and diversity of boats which can be expected, two boat lift systems are planned: a fork lift type and a hoist type. Both are described below. For details on boat lift facilities, see Table 9-1 and the Drawings and Specifications.

Proposed for this application is a 20-ton capacity Travel Lift crane which is self-propelled and supported on four running wheels that will be supported on finger piers built integrally with the cofferdam. This equipment has a clear inside dimension of 15 feet. Two automatically controlled and energized flexible saddles or slings can be adjusted to accommodate each boat at the bow and stern to provide support during lifting and transport to the other side of the dam. Boats without the typical hull configuration (such as houseboats with pontoons) would require special supporting methods. For the average 30 foot inboard-outboard motorboat using the Dead River, it is estimated that about 10 minutes will be required to transport the craft from one side of the dam to the other using the crane facility. A system of docks and temporary walks will be installed to convey occupants of boats from one side of the dam to the other.

For smaller boats, a 12.5 ton self-propelled, marine fork lift will be used to transport boats from one side of the cofferdam to the other. This fork lift will handle boats from 10 feet to 26 feet in length.

In addition, a removable section has been included in the cofferdam design. This passageway will permit boats to pass freely during the refill phase (when water will be flowing out of Lake Harris and into Lake Eustis). During the drawdown and holddown phases of the project, the passageway will be sealed (with wooden stop logs) so as to maintain the integrity of the dam. For details, see the Drawings and Specifications.

The site will require housing for the operator, radio equipment, maintenance and repair equipment. An existing building at this site which is presently unoccupied will serve this purpose satisfactorily. An existing access road from U.S. 441 to the abandoned building and the river's edge will meet the requirements of this project with the provision that a suitable turn around facility be provided for trucks and construction equipment.


NOTE
▬
FOR DETAILS, SEE DRAWINGS & SPECIFICATIONS.
441
EXISTING DWELLING TO BE USED AS BOAT LIFT OPERATORS STATION
FILLED AREA FOR FORK LIFT OPERATION
FLOATING DOCKS
SHEET PILE
SUPPORT RUNWAY FOR SELF-PROPELLED BOAT LIFT
REFILL BOAT PASSAGE
ADJUSTABLE STOP LOG WEIR
SINGLE ROW OF STEEL SHEET PILE
SEABOARD COASTLINE RAILROAD
DEAD RIVER
N
441

Dead River dam and boat lift facility.

FIGURE 9

Visual water level gages will be installed on either side of the dam so that the elevation of both Lakes Harris and Eustis can be monitored.

## 9.08 LAKE BEAUCLAIR PUMPING STATION

### A. General

The second of three refill pumping facilities will be located at the Lake Beauclair end of the Apopka-Beauclair Canal (see Figure 9-9). A cofferdam will be built across the end of the canal to support the pumping equipment and water will be lifted from the lake into the canal for conveyance to Lake Apopka. Before reaching Lake Apopka, a third refill pumping facility will be required near the Apopka-Beauclair Canal Lock and Dam. The Lock and Dam facility is described later. Details of the Lake Beauclair facility follow below.

### B. Cofferdam

At the end of the holddown period, the water level in Lake Beauclair will be about 64 feet MSL. The existing ground near the end of the Apopka-Beauclair Canal is about 65 feet MSL. A cofferdam will be built across the width of the canal (about 120 feet) and tie into the existing ground along both banks. For design details, see Table 9-1 and the Drawings and Specifications.

### C. Access

A private farm road running from Shirley Shores Road to the citrus grove along the west side of the canal will be used for access to this site. The road must be extended a short distance from the end of the groves to the canal and upgraded to handle heavier and wider vehicles. Upgrading will probably consist of widening the road to about 20 feet, providing parking and a turn around at the site and adding sand or other suitable fill material to wet areas and low spots. Also, a few fruit trees near the site may have to be removed during construction. At the conclusion of the project, the road could either be restored to its original condition or left as modified at the owner's discretion. Compensation will also be required for fruit tree damage.

### D. Sump and Protective Barriers

For the pumps to function properly over the range in lake levels expected during the refill phase and the Lake Beauclair restoration phase (during which Lake Beauclair will be lowered to 53 feet MSL), an adequate water depth must be maintained over the entrance to the suction pipes. Since about 12 feet of water is necessary, a sump must be excavated to 41 feet MSL. To provide enough space for five suction pipes, the sump must be about 30 feet wide and 50 feet long. The bottom of the sump will be lined with large riprap (described earlier in the drawdown facilities) to prevent scouring of bottom sediments.

Sheeting driven around the sump in preparation for the excavation will be left in place and cut off at about 52 feet MSL to allow water to enter the sump but not silt and other bottom debris. Upstream of this sheeting will be a wildlife net to keep turtles, alligators and other wildlife away from the pumps. A vegetation barrier will be attached to piles driven into the channel bottom just upstream of the wildlife net. The wildlife net will extend to the bottom of the canal while the vegetation barrier will only reach about 2 feet below the water surface.

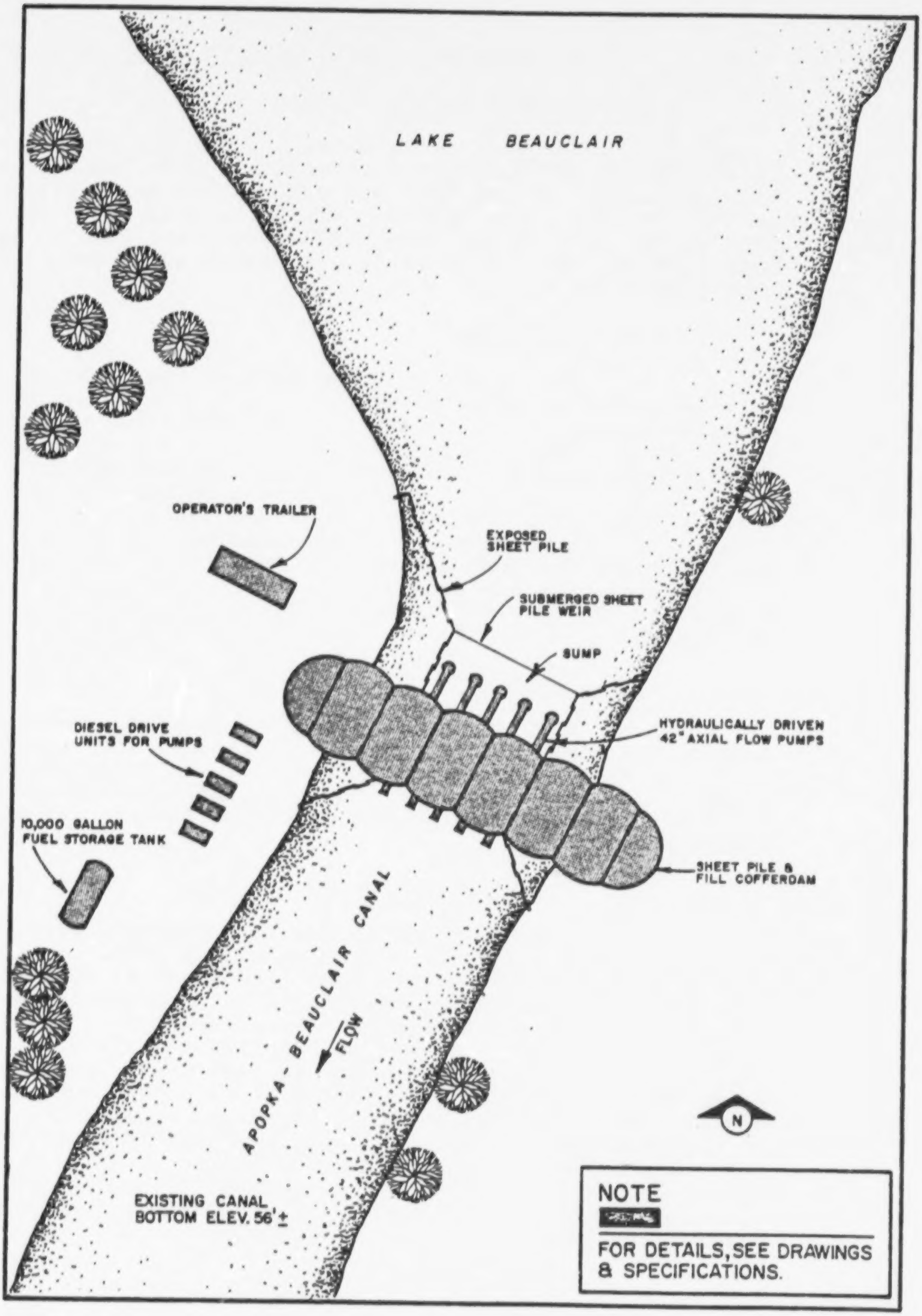
### E. Pumps

Five of the 430 HP diesel powered 42-inch axial flow pumps used during the drawdown and holddown phases on Lake Apopka will be transferred to the cofferdam to pump refill water (366 cfs) from Lake Beauclair into the canal. (See Section 9.04 for a more thorough description of the pumps.) Four pumps are needed to maintain the required flow while the fifth will be in reserve. Riprap will be installed on the canal bottom and side slopes on the discharge side of the dam to provide additional scouring protection. See Table 9-1 and the Drawings and Specifications for details.

### F. Fuel, Operation Control and Noise

Because this site is relatively remote, diesel driven pumps will be used. A 10,000 gallon fuel storage tank will be installed on shore which should provide about a two week fuel supply. Noise should not be a problem for neighboring residents as the distance to the nearest permanent residential dwelling is about 1/2 mile. However, should control be necessary, temporary enclosures could be built around the pumps with accoustical panels to reduce the noise.

A small mobile trailer will be provided with a two-way radio to link the pump operator with the main operation control center at the Lock and Dam on the Apopka-Beauclair Canal. The trailer will provide shelter for the operator and storage space for miscellaneous supplies.


LAKE BEAUCLAIR
OPERATOR'S TRAILER
EXPOSED SHEET PILE
SUBMERGED SHEET PILE WEIR
SUMP
HYDRAULICALLY DRIVEN 42" AXIAL FLOW PUMPS
DIESEL DRIVE UNITS FOR PUMPS
10,000 GALLON FUEL STORAGE TANK
SHEET PILE & FILL COFFERDAM
APOPKA - BEAUCLAIR CANAL
FLOW
N
EXISTING CANAL BOTTOM ELEV. 56'±
NOTE
FOR DETAILS, SEE DRAWINGS & SPECIFICATIONS.

Lake Beauclair pumping station.

FIGURE 9-9

## 9.09 APOPKA-BEAUCLAIR CANAL LOCK AND DAM PUMPING STATION

### A. General

The last of three refill pumping facilities will be located in the Apopka-Beauclair Canal just downstream (towards Lake Beauclair) of the Lock and Dam. A cofferdam will be built across the canal just upstream of the Astatula Road overpass to control the canal water level and support the pumping equipment. This facility and its operation is described in detail below (see Figure 9-10).

### B. Cofferdam

During the holddown period, the Lock and Dam gates will be opened to allow canal water to flow by gravity to Lake Beauclair. During refill the Lock and Dam gates will again remain open. However, the flow will go in the opposite direction towards Lake Apopka. The existing ground near the Lock and Dam is about 70 feet MSL. A cofferdam will be built across the width of the canal (about 100 feet) and tie into the existing ground along both banks. The cofferdam will be 15 feet wide to provide space for pump equipment. Because of soil conditions in this area, vehicle access will not be permitted across this cofferdam. See Table 9-1 and the Drawings and Specifications for details.

### C. Access

A dirt road leading from Astatula Road to the east bank of the canal will be used for access to the site. The road will require some modifications as the grade may be too steep for heavier vehicles. Upgrading will consist of reducing the grade to Astatula Road and providing parking and a turn around at the site.

### D. Sump and Protective Barriers

For the pumps to function properly over the range of water levels expected in the canal (the level on the suction side of the cofferdam should drop from about 64 feet MSL to 60 feet MSL) an adequate water depth must be maintained over the mouth of the suction pipes. Because about 12 feet of submergence is necessary and the canal bottom is about 57 feet MSL, a sump must be excavated to 48 feet MSL. To provide adequate space for four suction pipes, (the fifth pipeline which is part of the reserve unit will not be installed to minimize excavation of the canal banks), the sump will be about 30 feet wide, and 40 feet long. The bottom of the sump will be lined with large riprap (described earlier in the drawdown facilities) to prevent scouring of bottom sediments. For details, see Table 9-1 and the Drawings and Specifications.

### E. Pumps

Four of the 430 HP diesel powered 42-inch axial flow pumps used during the drawdown and holddown phases on Lake Apopka will be installed on the cofferdam to pump the required flow (366 cfs) to Lake Apopka. A fifth pump of equivalent capacity will be installed on the cofferdam to serve as a reserve pump. (See Section 9.04 for a more thorough description of the pumps.) In addition, riprap will be installed on the canal bottom and side slopes on the discharge side of the cofferdam.

### F. Fuel, Operation Control and Noise

Because this site is remote, diesel pumps will be utilized. A 10,000 gallon fuel storage tank will be installed which will provide about a two week fuel supply. Should noise control be necessary, temporary enclosures could be built around the pumps with accoustical panels or sound dampening material to reduce the noise.

This station will be the main control point during the refill phase. The other refill stations will be linked to this facility by radios and this station's operator will monitor the refill efforts and dictate instructions. A mobile trailer will provide shelter for the operator and storage space for miscellaneous supplies.

## 9.10 CITRUS IRRIGATION

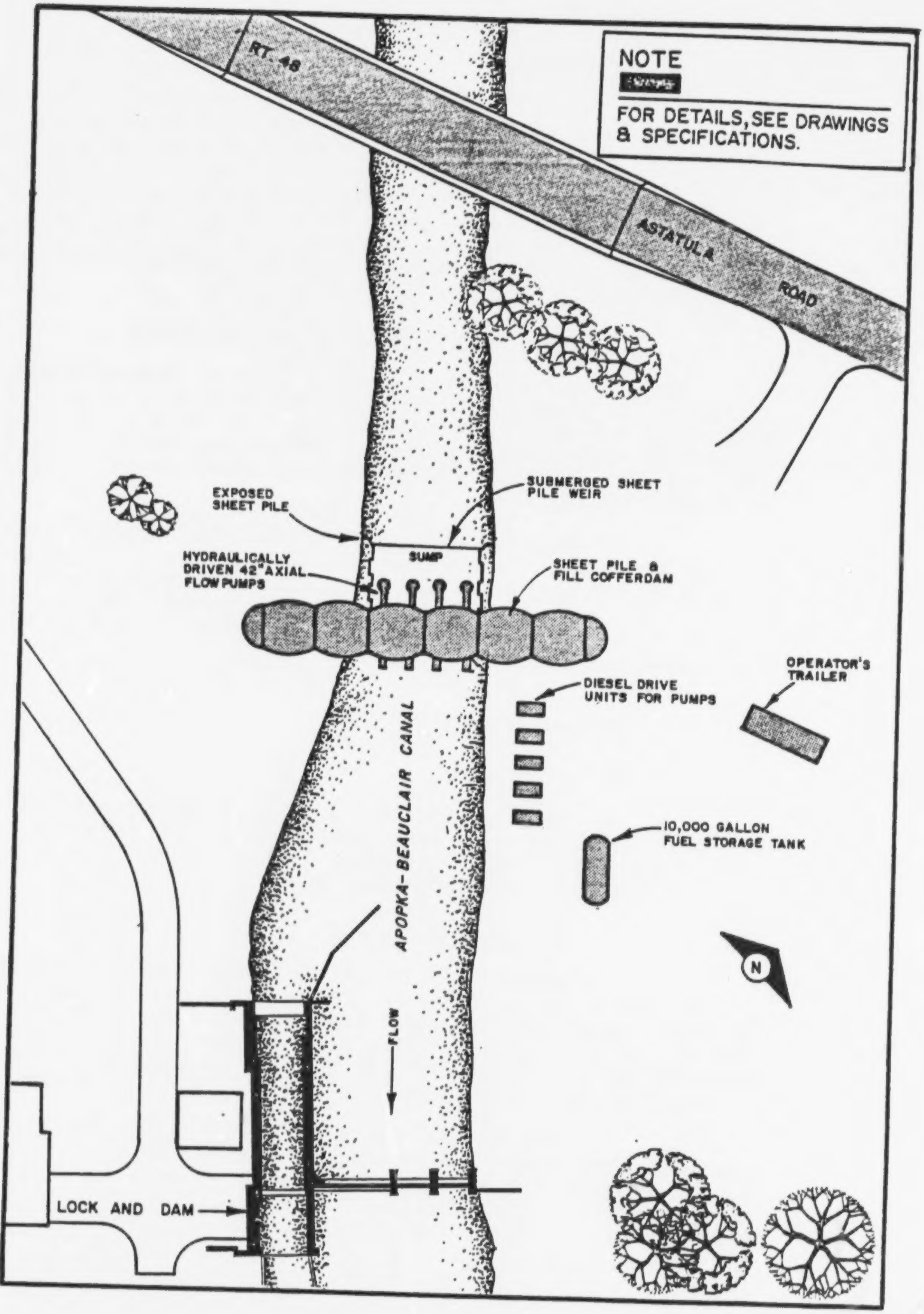
### A. General

The methods of fulfilling the irrigation needs of the citrus groves near Lake Apopka have been previously described in Section 6.03. The necessary facilities and the operation of those facilities are described below.

### B. Facilities

Wells will be drilled prior to drawdown and used as irrigation water supply. These wells will be ten inches in diameter, approximately 400 feet deep and will be cased to the top of the limestone. Pumps will be vertical turbine type, with capacity of approximately 500 gpm. Pump motors will be electric or gasoline powered, depending on exact well location.

For groves which currently irrigate from the lake, the well pump outlet will connect to the inlet of the irrigation pump. In the case of community wells for small, abutting groves, the distance between the well and irrigation pump inlet will be traversed by aluminum pipe utilizing high pressure couplers.


NOTE
[redacted]
FOR DETAILS, SEE DRAWINGS & SPECIFICATIONS.
RT. 48
ASTATULA ROAD
EXPOSED SHEET PILE
SUBMERGED SHEET PILE WEIR
SUMP
HYDRAULICALLY DRIVEN 42" AXIAL FLOW PUMPS
SHEET PILE & FILL COFFERDAM
APOPKA-BEAUCLAIR CANAL
DIESEL DRIVE UNITS FOR PUMPS
OPERATOR'S TRAILER
10,000 GALLON FUEL STORAGE TANK
N
FLOW
LOCK AND DAM

Apopka-Beauclair Canal Lock and Dam pumping station

In the case of groves which do not have an irrigation system, irrigation water will be applied by velocity guns mounted on portable risers. The velocity guns can typically apply 500 gpm to an area 425 feet in diameter. The risers will be connected to the supply wells by aluminum pipe and flexible hose.

C. Operation

Groves which are currently irrigated from the lake will use the wells as water supply, and can, therefore, be irrigated at the discretion of the manager of the grove.

In the case of groves not currently irrigated, irrigation will be dependent on the velocity gun risers. Irrigation of these groves will be scheduled to conform as much as possible to the grove manager's request. Risers will be relocated by tractor or truck.

## 9.11 ORGANIC SOIL FARM IRRIGATION

### A. General

Irrigation water needs and sources of water for the organic soil farms north and east of Lake Apopka have been previously described in Section 6.04. The following describes the necessary facilities and the operations of those facilities.

### B. Facilities

Water will be transported to these farms via existing canals. Necessary enlargements, repairs and connections have been previously described in Section 6.04. Screw gates and flashboard risers will be used to regulate flow into the various canals.

### C. Operation

Operation of the screw gates, flashboard risers and pumps will be left to the farm managers so as to allow maximum coordination with their irrigation needs and schedule.

## 9.12 LAKE BEAUCLAIR RESTORATION FACILITIES

### A. Lake Beauclair Deep Hole Channel

A deep hole channel will be necessary to facilitate the drawdown and holddown of Lake Beauclair. The channel will be approximately 3000 feet long and 60 feet wide at the base with 15:1 side slopes and a channel invert of 47 feet MSL. The channel will be dug by a floating hydraulic dredge.

### B. Pumping Stations

The pumping stations located at Lake Beauclair and at the Apopka-Beauclair Canal Lock and Dam (which were used during the refill of Lake Apopka) will be operated for drawdown and holddown of Lake Beauclair. These pumping stations have been previously described in Sections 9.08 and 9.09, respectively.

### C. Cofferdams

Two cofferdams are required to prohibit flow into Lake Beauclair during drawdown, holddown and refill. These will be located at the connections of Lake Beauclair with Lake Dora and with Lake Carlton.

At the Lake Dora connection, the cofferdam will span approximately 800 feet and will consist of a single row of sheeting.

At the Lake Carlton connection, the cofferdam will span about 90 feet and will consist of a single row of sheeting. A portion of that sheeting will be driven to 63.5 feet MSL to maintain Lake Carlton below 64.0 feet MSL. For additional facts on these cofferdams, check Table 9-1 and the Drawings and Specifications.

### D. Refill Facilities

No additional facilities will be required for refill. The Apopka-Beauclair Canal Lock and Dam pumping station will be completely removed prior to refill of Lake Beauclair. The Lake Beauclair pumping station will be modified to permit gravity refill of Lake Beauclair from Lake Apopka without dewatering the north end of the Apopka-Beauclair Canal. For specifics, see the Drawings and Specifications.

## 9.13 DIKE PROTECTION

It is extremely important to protect all dikes during the restoration project, those along the north shore of Lake Apopka, the Apopka-Beauclair Canal, and the East-West and North-South McDonald Canal. Various methods of protecting the dikes are discussed below. For further details, see the Drawings and Specifications.

Exploratory soil tests, specifically Static Cone Penetration tests, were performed at selected locations along the dikes. Dikes were also inspected by a geotechnical engineer for general conditions, materials and method of construction, etc. Typical cross sections were surveyed, and farm managers and owners were interviewed.

Based on these field data it is apparent that no accepted engineering procedures were used in the design and construction of the dikes. Typically, dikes were constructed by excavating available materials (usually muck or calcareous clay) and placing them to create a dike. As the material consolidated, additional material was excavated and placed on top of the dike, eventually producing the dike which exists today.

In general, the existing dike can be described as highly variable. Dike and foundation materials are very weak soils, typically muck or calcareous clay. In the past, the dike has failed and been repaired with available materials, including hay bales, automobile bodies, school buses, etc.

Over 32 miles of dikes will be impacted in some way (either by exposure to high water levels), during the course of this project. Length of the dikes, the variability in materials and condition of each dike, and the generally poor structural properties of the soils encountered effectively prohibits the suggestion of a "typical" minimum section to which the dikes must conform. While the geotechnical work performed during the design phases has expanded the data base regarding these dikes significantly, much more geotechnical information is needed to cost-effectively and realistically delineate areas of the 32 miles of dikes which must be improved. In light of this, and the dynamic state of these dikes, (regularly experiencing consolidation and subsequent improvement by concerned farmers), any recommended "typical" improvements would not necessarily accurately describe the problem areas of the dikes at the point in time when the restoration project proceeds.

Therefore, the best approach is a plan of extensive soil explorations, immediately before proceeding with the construction phase of the restoration project. During the initial construction phase, the contractor will perform extensive soil exploration of the dikes. Such information will be used to accurately delineate the weakest areas. These areas will be reinforced with steel sheeting or soil stabilization fabric, or by replacing inferior material with suitable granular fill.

In addition, control cross sections will be delineated; bench marks will be established and preserved. Cross sections will be surveyed prior to the project, and regularly during the course of the project, to accurately monitor all changes in dike elevations. Survey data will be used to predict any problems, so that there will be as much time as possible to institute improvements and/or repairs prior to dike failure.

In addition, the dike will be regularly patrolled and inspected for signs of failure. Farm managers whose land abuts these dikes will be regularly contacted regarding any changes of pumping rates, seepage, etc., which might precede dike failure. Any noted problem areas or suspected weak spots will be protected with sheeting, stabilization fabric, etc. until permanent repairs can be affected.

However, even with a thorough and regular dike monitoring program, sudden failure at some point along the dike may occur. The contractor will maintain sufficient materials on hand to repair dike failure as quickly as possible. Sheeting, temporary cofferdams, and/or traditional methods will be used to temporarily stop flooding until sufficient fill can be placed to assure dike integrity. Nonetheless, the Department must take all possible steps to predict and avert dike failures to minimize exposure to the potential liabilities associated with such sudden failures.

It is important of note that the greatest possibility for sudden dike failure exists after the refill of Lake Apopka to 64 feet MSL is completed. During this period of time, the lake will continue to rise naturally. During the displacement, shear forces will increase as the water level rises, until they reach maximum when the lake reaches its normal operating level (between 66.0 feet MSL and 67.0 feet MSL). It is at this time that chance of dike failures, resulting from the restoration project, is the greatest. Therefore, dike monitoring and protection must continue long enough after refill completion to demonstrate the structural integrity of the dike. Again, this will help minimize the exposure of the Department to the liabilities associated with dike failures after project completion.

## 9.14 SETTLEMENT OF SHORELINE STRUCTURES

Approximately 85 to 90 structures are located near enough to the shoreline of Lake Apopka to be potentially impacted by the dewatering of soils from drawdown of Lake Apopka. As a result of this dewatering and depending on the soil type, significant soil consolidation and settlement may result. If this occurs beneath an existing structure, settling of that structure typically does occur, resulting in cracks in the walls, floor and foundation.

To protect property owners from damages which might result from settlement of shoreline structures and to protect the Department from liabilities which might result from such damages, these structures which may be impacted by the drawdown of Lakes Apopka and Beauclair (including those at other facility sites) will be inspected by a geotechnical engineer. Structures will be photographed and accurately documented and described. All existing cracks and other signs of previous settlement will be noted and documented. Exploratory soil tests will be performed as necessary. Benchmarks will be established and spot elevations determined as necessary.

This information will then be evaluated by the resident project engineer and actions taken, where appropriate, to prevent settlement damage. Actions will include the use of fill, sheeting and pilings to protect the structures. Where conditions do not merit such precautionary actions, the structures will be monitored;

if settlement of any of these structures does occur, steps will be taken to minimize additional settling. Again, this will be by the use of fill, sheeting or pilings.

Sometime after project completion, all structures inspected before start up of the project will be reinspected. All structures will be photographed and accurately documented and described, to note any sign of settlement occurring during the project. This will be done to protect the Department against any future claims which might be attributed to the restoration project.

## REFERENCES

1. Schneider, R. F., and J. A. Little. Characterization of Bottom Sediments and Selected Nitrogen and Phosphorus Sources in Lake Apopka, Florida. United States Department of the Interior, Federal Water Pollution Control Administration, Southeast Water Laboratory, Athens, Georgia. March 1969.

# SECTION 11

# ESTIMATED COST OF PROJECT

## 11.01 GENERAL

This section presents the estimated cost of all labor, materials, supplies, equipment and appurtenances necessary to conduct the Lake Apopka Restoration Project, as described in this report and companion documents (Drawings and Specifications). As this estimate is based on the project as delineated by the final design, it is referred to as the final cost estimate. The differences between the preliminary cost estimate (presented in the Preliminary Engineering Report, dated October 1978) and the final cost estimate is also discussed in this section.

## 11.02 PREPARATION OF FINAL COST ESTIMATE

Quantities of materials, equipment, work, etc. necessary to construct, operate, maintain and remove the various project components (previously described in this report) were derived from the Drawings. Details regarding materials, equipment, field conditions, methods of construction, etc. were determined from the Specifications. These quantity takeoffs were compiled so that unit prices for the various items could be applied to estimate the total project cost.

Attempts were made to compile prices for various work elements that would be representative of the contractor's bid price. Manufacturers were contacted with regard to the prices of selected mechanical equipment (i.e., pumps, boat lifts, etc.), and price quotes were obtained from suppliers for major materials (i.e., steel pipe, sheet pile, etc.). Unit prices for miscellaneous materials were obtained from contractors or from current cost estimating guides. The cost of labor necessary to install major equipment and materials was based on manufacturers' experience with similar jobs in Florida, contractors' estimates and information derived from cost estimating guides.

The degree of accuracy in estimating prices and quantities for earthwork was not as high as for other elements of work. In some cases (i.e., cofferdams at the various pumping stations) the amount of earthwork required could be accurately estimated. However, the unit cost associated with performing the work was much more difficult to estimate, as the cost is heavily influenced by the poor soil conditions and the time frame during which the work must be performed.

As a result, the estimated unit price for earthwork was based largely on experience and judgement.

While in some cases the unit prices for certain types of earthwork were readily determined, the amount of work required was much more difficult to estimate. In the case of dike protection and/or repair, typical unit costs associated with placing and compacting fill material were readily available (from recent jobs in the area, etc.); however, the quantity of backfill needed for the 32 miles of dikes which will be impacted, was much more difficult to estimate. As a result, the estimated cost of earthwork was based heavily on engineering judgement. In the case of dredging, this judgement was aided by dredging contractors who visited the site, made various measurements and suggested a unit price based on actual field conditions.

In each case, the estimated unit quantity of work was multiplied by the respective unit cost. Component costs were summed and the total cost associated with the installation, operation, maintenance and removal of each of the various facilities was determined.

## 11.03 TOTAL CONSTRUCTION, OPERATIONAL AND RELATED COSTS

### A. Construction Cost

The construction cost for each of the facilities and components associated with the Lake Apopka Restoration Project are summarized in Table 11-1. The total construction cost, including overhead and profit, but excluding insurance cost is estimated to be $17,517,600.

### B. Operational Cost

The costs of operation during the drawdown, holddown and refill phases are summarized in Table 11-1. Included in this estimate is the necessary labor for 24-hour operation at each of the pumping stations, as well as sufficient personnel to maintain the pumps, drive units and other equipment throughout the restoration period. Also included in the labor estimate is sufficient manpower to operate the other facilities as previously described in Section 10.

Fuel and electrical power costs are estimated on the previously discussed energy consumption rates (see Section 10) for design rainfall conditions (i.e., those conditions which result in 24-hour, 7-days per week pumping during the 9-month drawdown, holddown and refill sequence). If design rainfall conditions do not occur (i.e. less water has to be pumped than was designed for), costs associated with energy consumption could be lower than estimated.

## TABLE 11-1

## ESTIMATE OF
## CONSTRUCTION, OPERATIONAL AND RELATED COSTS
(March 1979 Dollars)

### Construction Cost

| Item | Estimated Cost |
|---|---|
| Lake Apopka Deep Hole Channel and In-Lake Sedimentation Basin | $ 3,671,100 |
| Lake Apopka Pumping Station | 2,253,900 |
| Lake Apopka Water Control Structure | 35,600 |
| Lake Dora Pumping Station | 1,098,000 |
| Lake Dora Energy Dissipator | 22,000 |
| Dora Canal By-Pass Pipeline | 2,232,600 |
| Lake Eustis Energy Dissipator | 275,100 |
| Lake Eustis Pumping Station | 75,500 |
| Dead River Dam & Boat Lift | 601,200 |
| Lake Beauclair Pumping Station | 513,300 |
| Apopka-Beauclair Canal Lock and Dam Pumping Station | 255,500 |
| Lake Beauclair/Lake Dora Cofferdam | 159,500 |
| Lake Beauclair/Lake Carlton Cofferdam | 22,900 |
| Citrus Irrigation | 1,238,500 |
| Silt Removal and Canal Protection | 401,000 |
| Dike and Shoreline Protection | 2,975,400 |
| Muck Farm Irrigation | 1,024,800 |
| Removal of Facilities & Cleanup to Pre-Construction Conditions | 461,700 |
| General Requirements (Mobilization, Construction Office, etc.) | 200,000 |

Subtotal: $17,517,600

### Operational Cost

| Item | Estimated Cost |
|---|---|
| Labor (24 hours per day operation) | $ 692,200 |
| Diesel Fuel, Electric Power, Filters, Belts, etc. | 1,237,400 |
| Irrigation Operation | 52,200 |
| Miscellaneous Supplier, Materials and Supplies | 44,100 |

Subtotal: $ 2,025,900

### Insurance

| Item | Estimated Cost |
|---|---|
| Allowance for liability insurance premium for construction and operational phases and other required insurance | $ 1,000,000 |

### Credit For Salvage

| Item | Estimated Cost |
|---|---|
| Axial Flow Pumps and Drive Units | $ 1,316,400 |
| 84-Inch Diameter Steel Pipe | 468,600 |
| Boat Lift Facilities | 106,700 |
| Irrigation Equipment | 377,200 |
| Miscellaneous Equipment | 22,400 |

Subtotal: $ 2,291,300

Operational costs summarized in Table 11-1 include the cost associated with the Lake Beauclair restoration phase of the Lake Apopka Restoration Project.

### C. Insurance

Due to the contingent liabilities associated with the project, as delineated in Section 13, the cost to the contractor for the required insurance and bonds will be very high. One million dollars was estimated to be the cost of the bid bond, performance bond, payment bond, workmens compensation insurance, builders risk insurance and public liability insurance. Any steps taken by the Department to reduce the liability exposure of the contractor, would reduce the insurance premium, thereby reducing the cost of the project.

### D. Salvage

Estimated value of salvage of selected materials and equipment used in the project is summarized in Table 11-1 and amounts to $2,291,300. The salvage value of axial flow pumps and drive units was estimated at 50-percent of purchase price; 84-inch steel pipe at 30-percent of material cost. The salvage value of the boat lift and marine fork lift were estimated to be 50-percent and 70-percent of purchase price, respectively. Deep well pumps (used for citrus irrigation) were estimated to bring a salvage value of 50-percent of the purchase price. Estimating prices used for sheet pile included installation, removal and return to leasing company, therefore, no salvage credit was allowed for this item.

All credit for salvaged equipment will be realized at the conclusion of the project.

## 11.04 OTHER COSTS

The other costs associated with the Lake Apopka Restoration project are summarized in Table 11-2. These costs include real estate, engineering and miscellaneous technical services. Each is discussed below.

### A. Real Estate

It will be necessary to acquire approximately 50 acres of land for easements, rights-of-way, etc. for the project facilities. The estimated cost of $50,000 presented in Table 11-2, includes the legal, surveying and other costs required to acquire the property.

### B. Engineering

The cost estimate of the engineering services needed for the bidding, bid evaluation, construction inspection and operational phases of the project is presented in

## TABLE 11-2

## ESTIMATE OF
## REAL ESTATE, ENGINEERING AND MISCELLANEOUS TECHNICAL SERVICES
(March 1979 Dollars)

| Item | Estimated Cost |
|---|---|
| Real Estate (50 acres total, including surveying, appraisal, acquisition cost) | $ 50,000 |
| Engineering (Services during bidding, bid evaluation, construction and operational phases of the project) | 396,000 |
| Miscellaneous Technical Services (muck consolidation, limnological studies, water quality monitoring, etc.) | 75,000 |
| TOTAL | $521,000 |

Table 11-2. The cost provides for a resident engineer during the entire project (estimated at 34 months) and one inspector for 18 months. The resident engineer will also direct the operational phase of the project.

### C. Miscellaneous Technical Services

The cost of miscellaneous technical services the Department may require is estimated at $75,000, as shown in Table 11-2. This includes a variety of technical work which should be performed to monitor the impact of the restoration project on muck consolidation, water quality, etc.

## 11.05 TOTAL PROJECT COST

The estimated total project cost for the Lake Apopka Restoration Project is summarized in Table 11-3. The total project cost, in March 1979 dollars, is estimated to be $21,064,500. This includes the construction, operation, insurance and miscellaneous costs summarized in Tables 11-1 and 11-2. To account for anticipated increases in labor and material from March 1979 to July 1979 (date project is estimated to commence) and to provide for contingency, the total project cost was increased by 5-percent, resulting in a total project cost in July 1979, of $22,117,000. This does not include the credit for salvage of $2,291,300, nor does this estimate include any internal costs of the Department associated with this project. Net total project cost is estimated to be $19,826,400.

## 11.06 COMPARISON OF ESTIMATES OF TOTAL PROJECT COST

### A. Total Project Cost Estimate Presented in the Preliminary Engineering Report (October 1978)

The preliminary total project cost of the Lake Apopka Restoration Project was presented in the Preliminary Engineering Report, dated October 1978. The cost estimate for the project with a drawdown in the year 1981 is summarized below:

PRELIMINARY COST ESTIMATE

| | |
|---|---|
| Total Project Cost | $16,679,700 |
| Credit for Salvage | (1,759,700) |
| Net Cost | $14,920,000 |

The preliminary estimate was based on unit quantities and prices derived from the preliminary study, and represented the best estimate of the total cost at the time the estimate was prepared (September 1978).

## TABLE 11-3

## SUMMARY OF TOTAL PROJECT COST

| Item | Estimated Cost |
|---|---|
| Construction | $17,517,600 |
| Operational | 2,025,900 |
| Contractor's Insurance | 1,000,000 |
| Real Estate | 50,000 |
| Engineering Services | 396,000 |
| Miscellaneous Technical Services | 75,000 |
| Total Project Cost (March 1979 Dollars) | $21,064,500 |
| Allowance for increases in cost from March 1979 to July 1979 (estimated date of project commencement) plus contingency. | $ 1,053,200 |
| Total Project Cost (July 1979) | $22,117,700 |
| Less credit for salvaged equipment & materials | (2,291,300) |
| Net Total Project Cost | $19,826,400 |

### B. Total Project Cost Estimate Presented in the Final Engineering Report (March 1979)

The final estimate of total project cost, presented in detail earlier in this section of the report, is summarized below. This estimate is also for a pumped drawdown starting in March 1981.

FINAL COST ESTIMATE

| | |
|---|---|
| Total Project Cost | $22,117,700 |
| Credit for Salvage | (2,291,300) |
| Net Cost | $19,826,400 |

### C. Explanation of Cost Difference

The significant difference between the preliminary and final cost estimate (over $5.4-million) is due mainly to:

#### 1. Poor Soil Conditions

The field work conducted during the final design phase of the project proved that poor soil conditions were much more widespread than were anticipated in the preliminary report. The latest soil borings detected poor soil conditions not only in Lake Apopka; but under the Farmers Dike, along the Apopka-Beauclair Canal, at all pumping station sites and at the Dead River Dam and Boat Lift Site. The soils encountered at some sites offered zero to near zero resistance to the friction cone penetrometer at depths of up to 25 feet. Moreover, the standard penetration test revealed significant zero blow count material in select project areas. These weak soils necessitated significant revision in cofferdam design to provide adequate foundation and bearing for the pumping units. Heavier weight sheet pile sections, driven to greater depths than were originally estimated, are proposed to provide the required dam stability. Upgrading of sheet pile accounted for approximately $950,000 of the increase between preliminary and final cost estimates. Also the unusual soil conditions resulted in the revised design of the Farmers Dike. The dikes, both along the north shore of the lake and along the Apopka-Beauclair and McDonald Canals were found to be constructed on/or very weak soils which would experience significant consolidation during the drawdown process. Modifying the irrigation system and still providing adequate protection to the dikes increased project cost by some $2.3-million over the preliminary estimate.

Again, poor soils forced reconsideration of the materials used for the 84-inch pipe. The preliminary report proposed use of corrugated metal pipe; however, when the field work detected substantial deposits of muck in the railroad right-of-way (proposed route of pipeline), a decision was made to use steel pipe with welded joints. The steel pipe would prevent the pipe from disjointing should significant differential settlement occur. As the pipeline runs through a populated portion of Taveres, a break in the pipeline could not be tolerated. At the design flow rate (325 cubic feet per second), homes, structures, roads and automobiles in the vicinity of the pipeline would be destroyed in a matter of moments. Steel pipe with welded joints will afford maximum protection to the public, however, utilizing this material increased the cost of the project by some $350,000.

### 2. Project Uncertainties

The project is unique, and as such, historical cost comparison data is not available for most components of the project. Discussions with contractors during the design phase indicated that due to the magnitude and uniqueness of the project, and the significant risks involved, that the bid price would probably be higher than for a "standard" construction project. The prices used in the estimate, and the 5-percent contingency allowance ($1,053,200) are attempts to account for project uncertainties being reflected in the bid price.

### 3. Contingent Liabilities

The contractor selected by the Department to construct and operate the facilities will be exposed to enormous liabilities (as discussed in Section 13.05 of this report). To protect the contractor, an allowance of $1,000,000 is included in the cost estimate to pay for all insurance needed. without adequate coverage and protection to the contractor, it is doubtful that the state would receive any bids for the project. Only $200,000 for insurance was included in the preliminary estimate.

### 4. Construction Time

By lengthening the construction period, the cost of resident engineering will increase. An increase of $111,000 in engineering fees from the preliminary report resulted.

### 5. Pumping Units

To provide an extra margin of safety at the Lake Dora and Lake Eustis Pumping Stations, double stage pumps were specified in the final design. Only single stage pumps were proposed in the preliminary design. This change increased the total project cost by some $260,000.

Though these increases total over $6.1-million, this increase was offset by some cost reductions in the final design, resulting in the net increase of $5.4-million over the preliminary estimate. Operational labor cost, the costs of the Lake Beauclair/Lake Dora Dam and the Lake Beauclair/Lake Carlton Dam and costs associated with the subcomponents of some facilities were lowered by the final design.

# APPENDIX C

# ALTERNATIVE RESTORATION PROPOSALS

# Aeration

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# FEASIBILITY STUDY FOR THE RESTORATION OF LAKE APOPKA AND ITS ENVIRONMENTAL IMPACT

**Clean-Flo Laboratories, Inc.**
4342 SHADY OAK ROAD HOPKINS, MINN. 55343

DECEMBER 20, 1978

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## TABLE OF CONTENTS

PAGE

1. INTRODUCTION

  1.1 Narrative Summary 1

    1.1.1 Evaluation of the Condition of Lake Apopka 1
    1.1.2 Proposal for the Restoration of Lake Apopka 3
    1.2 Cost of the Proposed Action 6

2. LAKE INVENTORY 7

  2.1 Water Chemistry 7
  2.2 Physiology of Lake Apopka 20

    2.2.1 Aquatic Macrophytes 20
    2.2.2 Algae Data and Analysis 20
    2.2.3 Bottom Sediment Analysis 21
    2.2.4 Invertebrate Study 23
    2.2.5 Fish Study 24
    2.2.6 Microorganism Data 28
    2.2.7 Watershed Analysis 31

3. PROPOSED ACTION AND ALTERNATIVES 41

  3.1 Project Description 41
  3.2 Engineering Data 42
  3.3 Cost of the Proposed Action 46
  3.4 Alternatives 46

4. ENVIRONMENTAL IMPACTS 48

  4.1 Climate 48
  4.2 Air Quality 48
  4.3 Acoustics 49
  4.4 Water Quality 49
  4.5 Aquatic Biology 50
  4.6 Terrestrial Ecology 50
  4.7 Socio Economics 50

5. ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD PROJECT BE IMPLEMENTED 52

  5.1 With Construction of Project 52
  5.2 With Alternate Actions 52
  5.3 With No Action 52

PAGE

6. MEASURES UNDER CONSIDERATION TO MINIMIZE UNAVOIDABLE ENVIRONMENTAL EFFECTS 53

7. THE RELATIONSHIP BETWEEN LOCAL SHORT TERM USES OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG TERM PRODUCTIVITY 53

8. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION, SHOULD IT BE IMPLEMENTED 53

9. REFERENCES 54

LIST OF TABLES

Table 1. Bottom Water Chemistry 15
Table 2. Artesian Aquifer 15
Table 3. Surface Water 16
Table 4. Composite Readings 17
Table 5. Miscellaneous Influent 18
Table 6. Approximate Total Phosphorus and Nitrogen Input 19
Table 7. Aquatic Plant Seeds Found in Sediment 33
Table 8. Algae Data 34
Table 9. Sediment Survey and Analysis 35
Table 10. Sediment Chemistry 36
Table 11. Benthic Organisms 37
Table 12. Fish Management History 38
Table 13. Microorganisms Data 39
Table 14. Approximate Water Budget 40
Table 15. Costs for the Restoration of Lake Apopka 46

LIST OF FIGURES

Figure 1. Vollenweider Phosphorus Loading Model for Lake Apopka 9

# 1. INTRODUCTION

## 1.1 Narrative Summary

### 1.1.1 Evaluation of the Condition of Lake Apopka.

Lake Apopka is located at Winter Garden, Florida. It has about 30,671 acres of water averaging six feet deep, with depths ranging to 18 feet. Volume is about 58,650,000,000 gallons. An average of five feet of highly flocculant and organic sediment covers all but approximately 600 acres, with depths ranging to 40 feet.

The lake has been inundated by massive quantities of nitrogen, phosphorus, and other nutrients, primarily from muck farms and citrus groves. Next in order under these pollutants are nitrogen fixation from the atmosphere by cyanophyta, nutrient recycling from the sediment, direct rainfall, storm runoff, and Gourd Neck Spring. Compared to these sources, pollution from other industry, from the Winter Garden Sewage Treatment Plant, and private housing is minor.

Studies of Lake Apopka performed by Fox et al, 1977, Belanger, 1978 (1), Schneider, et al, 1969, and Orange County Pollution Control Department, 1971 indicate that significant deterioration of the lake has occurred since 1946.

---

(1) Thomas V. Belanger, 16 Jan. 1977. Florida Institute of Technology. Personal correspondence with Wm. Lutovsky, St. John's River Water Management District.

Prior to 1946, Lake Apopka was noted for its size and variety of game fish (Federal Writers Project, 1939), especially black bass. Many sporting publications heralded it as one of Florida's most popular freshwater fishing grounds. Today, the lake is dead to bass and other game fish, for all practical purposes.

As algae die, bottom sediment continues to accumulate at an ever-increasing rate. Periodically, the sediment/water interface becomes anaerobic. This releases massive amounts of nitrogen and phosphorus into the water. Ammonia and other gases released produces fish-kills. Ample nutrients are provided for blue-green algal growth, many of which species have toxic qualities. Benthic invertebrates are essentially nonexistent.

Cyanophyta and filamentous species have the ability to extract up to 80 pounds of nitrogen from the atmosphere, or up to one million kilograms nitrogen per year, for the entire lake. Likewise, carbon dioxide is extracted from the atmosphere.

The abundant influx of nutrients provides a medium for microorganisms, particularly staphylococci (sp.), which normally require a mucous medium to survive. The enormous quantity found (322,000/100 ml) is indicative of the nature of the medium supporting it (Belanger, 1978).

A study of the Vollenweider phosphorus loading model for Lake Apopka shows that to move the lake to the mesotrophic state would require at the very least, the cessation of all input from the muck farms, recycling from the sediment, direct rainfall, and Citrus Grove runoff. Such a requirement is totally unfeasible. Dredging, drawdown, or nutrient diversion would do little to halt this massive nutrient inflow, since direct rainfall and storm runoff alone is approximately equal to the maximum permissible loading, according to the Vollenweider model (see Figure 5 and Tables 6 and 15). Consequently, we feel that a totally innovative in-lake restoration method must be considered. This method would cycle incoming nutrients into a balanced food web.

### 1.1.2 Proposal for the Restoration of Lake Apopka.

Effective restoration strategy for Lake Apopka would have to eliminate or control the causes of the rapid deterioration.

To restore the lake for bass will require that the gases toxic to bass, particularly ammonia and hydrogen sulfide, be reduced to safe levels, and that dissolved oxygen be maintained above 4 mg/l. The bass would not survive, or increase, however, until a biota of benthic organisms is reestablished as a food source for the bass.

In order to establish a benthic community, it is also necessary that the interstitial water be oxygenated and rid of toxic gases.

In establishing a benthos, the invertebrates will feed on the organic sediment, consuming it and the nutrients it contains, much the same as snails are known to feed on sediment in aquaria. The result will be a conversion of the sediment into food for invertebrates which in turn will become food for fish. Five hundred pounds of fish contain approximately one pound of phosphorus and two tons of dried aquatic plants contain approximately one pound of phosphorus (Neel, et al, 1973).

If the phosphorus is permitted to be recycled into the water through an anaerobic environment, and if incoming nutrients cannot be consumed by fauna, then the phosphorus will become food for aquatic plants rather than food for fish. Thus, it is important to keep the bottom waters aerobic.

Keeping the interstitial waters aerobic will prevent the release of phosphorus and nitrogen, which presently is one of the major sources of nutrients for algae. It is important that these nutrients be reduced in the water column, or any artificial or natural clearing of the water would immediately trigger a massive aquatic macrophyte growth. By keeping the interstitial water aerobic as the nutrients are converted into a faunal food web, the bottom acts as a nutrient sink for all dying organisms, fecal droppings, and for various metallic phosphates which are continuously forming, and precipitating to the bottom. An important part of this process will also be to drive off carbon dioxide through multiple inversion, in order to permit phosphorus precipitation.

As the water is cleared of excessive nutrients, the pathogenic microorganisms will also decline. Many pathogenic microorganisms die immediately in oxygenated water. As it is cleared of excessive algal blooms, ultraviolet light can be more effective in weakening the microorganisms or even killing them directly. This process will be accelerated by a multiple inversion of the water, which will continuously expose the microorganisms to the surface of the lake.

To accomplish the above goals, two processes are herein recommended: 1- Multiple inversion of the water to oxygenate the bottom and drive off or deactivate toxic gases; to condition the water, including the reduction of carbon dioxide so natural calcium and other metallic ions in the water can combine with phosphorus, and to reestablish a food web between incoming nutrients, bottom organic sediment, and game fish, 2- Seeding the benthos with beneficial organic sediment-consuming microorganisms to more quickly reestablish a web of faunal life.

To accomplish the desired goals will require a multiple inversion system using 728-hp. 2912 Clean-Flo microporous ceramic diffusers will be placed on the bottom and connected to compressors located at 70 land-based stations and 112 floating stations, by means of 2,912,000 feet of weighted tubing radiating out from each compressor station along the lake bottom to the diffusers.

In addition, 35,208 gallons of sediment-feeding bacteria in a liquid solution containing 9,000,000 live microorganisms per gram will be seeded into the lake in order to quickly reestablish a food web. These organisms will also feed on phosphorus, nitrogen, and suspended matter in the water, and will become food for higher invertebrates, which then become food for fish.

### 1.2 Cost of the Proposed Action.

Cost for the proposed action is $11,259,000, based on today's prices. This compares with $13,900,000 for drawdown not including herbicide, possible repeated drawdowns, or dredging costs.

# 2. LAKE INVENTORY

## 2.1 Water Chemistry.

Water chemistry parameters, along with the other data gathered, are used by Clean-Flo Laboratories, Inc. to determine the amount of multiple inversion necessary.

The importance of the majority of these measurements is described below. Some of these measurements were not available on the lake studied.

A) Dissolved Oxygen (D.O.). Probably the most important measure of lake quality, D.O. is necessary for oxidizing wastes, including bottom sediments, and for purification of the water. Anaerobic bacteria, including coliforms, do not live in presence of high oxygen levels. Coliform bacteria are usually the result of pollution by sewage. Fish generally do not live at oxygen levels below 4 mg/l, and begin to die at 5 mg/l.

The oxygen level of this lake is above the unsafe level for fish, at the present time. Although there is no immediate danger, oxygen periodically drops to critical levels. The potential for this would be greatest after about five days of cloudy weather, when algal photosynthesis would be slowed and little oxygen added to the water by that process.

Oxygen oxidizes iron and manganese from the water. These two micronutrients are essential for all plant life. By removing anaerobic bacteria, bottom acids also are removed. This prevents inert phosphates, nitrogen compounds, and other nutrients from being redissolved into the water where they will encourage plant growth.

B) Phosphate. Not only is phosphate a key aquatic plant food, but by limiting phosphate, a plant's ability to absorb nitrates is restricted. Thus, control of phosphate will not only cause phosphate starvation in a plant, but eliminate the need to control nitrates as well. To accomplish this, phosphate must be reduced to less than 0.03 mg/l. Phosphate is a result of pollution due to fertilizer, human, animal, and plant residues, soaps, chemicals, natural deposits, etc. Presently, surface phosphate in Lake Apopka is average-to-high, but only because most of the phosphate is locked up in the algae mass and organic sediment. This is released as algae die and provide phosphate for new growth, and when the sediment-water interface becomes anaerobic.

Carbon dioxide and bottom acids release precipitated phosphate for plant consumption (Hephner, 1958).

Excessive nutrients in Lake Apopka is the major reason that this body of water has become eutrophic. It has been shown that by maintaining aerobic conditions over lake bottom sediments, the nutrient status of the lake can be improved (Fillos et al, 1976; Serruya, 1975; Kamp-Nielsen, 1975; Viner, 1975; Poon et al, 1976; Ripl, 1976; Fitzgerald, 1970; and Mortimer, 1941).

Our own research has shown even more benefits in the area of nutrient removal. To maintain phosphorus on the bottom in an insoluble form, anaerobic conditions must be destroyed, and this can only be done with adequate multiple inversion.

Approximate phosphate loading is given in Table 6. Figure 1 shows Lake Apopka to be in the eutrophic range, according to the model by Vollenweider (1969, 1976). To reduce the phosphorus loading to cause Lake Apopka

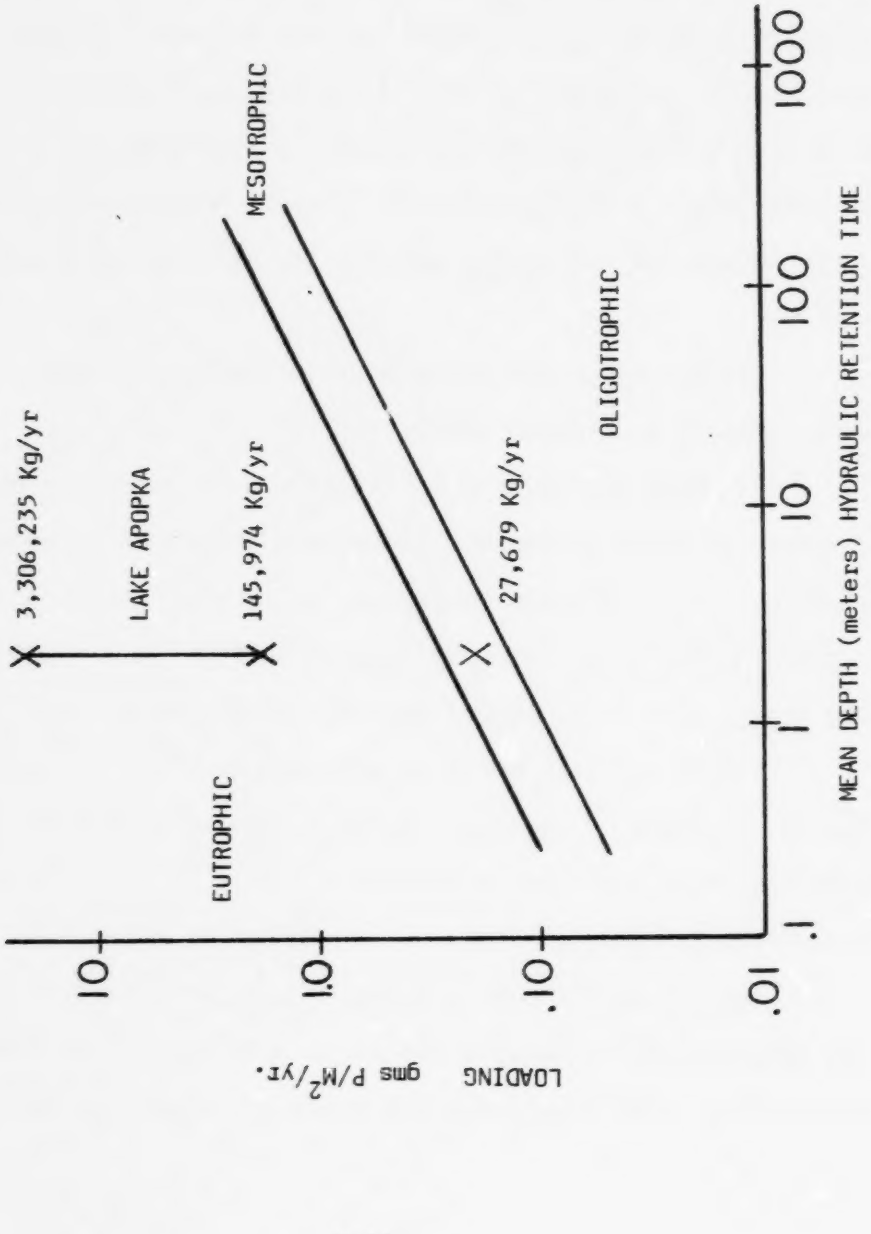

FIGURE I. Vollenweider phosphorus loading model for Lake Apopka

to fall within the mesotrophic range would require that it be reduced to 27,679 Kg P/yr, or a reduction of 81-99%, an unlikely possibility regardless of the extent of nutrient diversion. Fox et al, 1977 (p. 77) show an increase in orthophosphate and nitrate release from Apopka sediment upon drying. While multiple inversion would prevent the release of phosphorus and nitrogen from the sediment, only multiple inversion will cycle incoming nutrients into the faunal food web, and therefore we feel that multiple inversion is the only feasible restoration means for Lake Apopka.

C) Nitrogen. Nitrates in lake waters usually indicate runoff from heavily fertilized fields or feedlots, or wastes in the final stages of biological stabilization. Nitrite usually indicates stagnant conditions which can be corrected by multiple inversion. Nitrate is one of the prime foods for aquatic plants, and has been found to be greatly reduced by the Clean-Flo lake restoration process. The amount of total nitrogen required for lush aquatic plant growth varies from trace quantities to 5.3 mg/l.

Nitrogen loading for Lake Apopka is given in Table 6. This shows that all attempts to reduce nitrogen from the muck farms should be pursued with diligence. The second largest source of nitrogen is probably from nitrogen fixation by cyanophyta. This influx can be greatly reduced through reductions of cyanophyta by the Clean-Flo process. The third largest source of nitrogen is from the sediment. Again, this source will be minimized by multiple inversion, but will probably be increased if the lake is drawn down.

D) Ammonia nitrogen. This gas is produced in the water from fertilizer and from aquatic plant and animal decomposition. Clean, natural water has less than 0.1 mg/l. A higher value is an indication of high anaerobic activity. Organic muck is primarily a waste product of anaerobic activity.

At levels above 0.3 mg/l, some species of fish can suffocate. Ammonia is excessively high in Lake Apopka, with interstitial water reaching 10 mg/l.

E) Dissolved Iron. This micronutrient is essential for producing chlorophyll in aquatic plants. Taste threshold is 0.1 to 0.2 mg/l. Multiple inversion oxidizes this mineral nutrient out, while low pH and manganese redissolve it into the water, making it available for plant growth.

F) Calcium Hardness. The natural calcium in water can combine with phosphates to make them unavailable for plant assimilation, providing the water has first been adequately conditioned by the Clean-Flo multiple inversion process.

G) Magnesium and Total Hardness. These are measures of other nutrients available for plant growth. They appear in the water as the result of water contact with geological formation or from direct pollution by industrial or commercial operation. Bottom sediment is usually very high in these nutrients.

H) Alkalinity. This is an extremely important measure of water quality. The bicarbonate form of alkalinity supplies carbon dioxide for abundant plant growth. The Clean-Flo process will inactivate this plant food by converting it to carbonate.

I) Carbon Dioxide. Just as humans breathe in oxygen and exhale carbon dioxide, aquatic weeds must inhale carbon dioxide and exhale oxygen, in order to live. In addition, fish generally die at carbon dioxide levels greater than 25 mg/l. Carbon dioxide will keep phosphates dissolved in the water, so they are available for plant growth. The Clean-Flo lake restoration process will reduce the availability of carbon dioxide on a continuous basis.

J) pH. This is a measure of acid or alkaline activity and indicates water quality. Lakes should not be less than 6.0 nor greater than 10.0 for healthy fish life. Lake Apopka is often over 10.0, and it is important to decrease the pH level to 8.3-9.0. In order to lock up carbon dioxide availability for plant growth, and prevent precipitated nutrients from redissolving into the water, pH would be held above 8.0. Water quality standards are generally set at pH 6.5-8.5. Multiple inversion tends to hold pH near 8.3.

K) Secchi disk. This is a measure, in terms of feet, of water clarity. A low reading indicates high planktonic algae growth, or suspended materials in the water.

L) Biochemical Oxygen Demand. This is a measure of the demand for decaying organic matter to consume oxygen due to bacterial activity. Most regulatory agencies require that BOD from discharge sources into recreational lakes be less than 2, 10, or 20 mg/l. Multiple inversion will reduce BOD to near-zero after the oxygen has been supplied continuously over some period of time.

M) Hydrogen Sulfide. This is a poisonous and odorous gas which results from bacterial activity in the absence of oxygen. Levels higher than 0.4 mg/l can be harmful to fish. Normally, it should only be smelled by stirring bottom muck. Multiple inversion quickly inactivates this gas, and destroys the anaerobic bacteria which produce it.

N) Micronutrients. Micronutrients, or trace elements, are metals that are required in minute amounts for all plant life. By limiting one or more of these, plant and algae growth can be retarded.

Manganese is the oxidation-reduction catlyst for plants, regulating oxygen uptake and exhaust. Its limiting value is about 0.005 mg/l. Clean-Flo has consistently reduced manganese by oxidation in all lakes treated. Reducing it in Lake Apopka could help retard algae and aquatic plant growth. Manganese also breaks down phosphates which have precipitated out with iron in water, releasing the iron and the phosphate back into the water for plant and algae consumption (Hasler et al, 1948).

Molybdenum is the nitrogen fixation catylst necessary for plants to utilize nitrogen, while a deficiency of boron, (limiting value: 0.1 mg/l) produces a number of diseases in various plants. At present, no conclusive data is available on the effect of the Clean-Flo process of these two nutrients.

Zinc and iron are both required for enzymes which produce chlorophyll in plants, while magnesium is the singular center atom of the 137-atom chlorophyll molecule. With a lack of any of these three micronutrients, chlorophyll cannot be produced in a plant. Clean-Flo has documented reductions in iron and magnesium, while our studies have not shown an effect on zinc. Limiting value for zinc is 0.01-0.1 mg/l, while iron ranges from 0.00065 to 6.0 mg/l, and the value for magnesium is a "trace amount".

Reductions in calcium, sodium, potassium, and magnesium by the Clean-Flo process were documented by the Orange County Pollution Control Department in their studies of Lake Weston (Bateman et al, 1977). Limiting value for calcium is 20.0 mg/l; sodium 5.0 mg/l; and potassium and magnesium: trace quantities.

O) Tannin/lignin. Occurs naturally in water from trees or other vegetative decomposition, and causes a dark reddish-brown coloration in the water. Industrial wastes usually contain tannin, while lignin comes from paper pulp effluent.

P) Color, turbidity. Color is caused by industrial, residential, and natural pollutants, while turbidity is a measure of cloudiness or reflected light in water due to suspended particles. Generally accepted standard for color and turbidity are less than 30 APHA platinum-cobalt units for color and 10 JTU for turbidity. Lake Apopka color ranges from 30 to 160 white turbidity ranges from 11 to 27.

# WATER CHEMISTRY TABLES

The following average water chemistry data were obtained at three preselected test sites on 10/68, 1969-70, 1972-74, and 12-19-77, (1) (Brezonik *et al*, 1969), Brezonik *et al*, 1971), (Fox *et al*, 1977).

Table 1. Bottom Water Chemistry

| Measurement | Average Amount (Fox, *et al*, 1977) |
|---|---|
| Ammonia nitrogen (mg/l) | 10 |
| Orthophosphate (mg/l) P | 3.23 |

Table 2. Artesian Aquifer

| Measurement | Average Value |
|---|---|
| Total N, mg/l | 1.40 (165,157 lbs/yr) |
| Total P, mg/l | 0.07 ( 8,258 lbs/yr) |

(1) Thomas V. Belanger, 16 Jan 1977. Florida Institute of Technology. Personal correspondence with Wm. Lutovsky, St. John's River Water Mgmt. Dist.

Table 3. Surface Water

| Measurement | Oct.,1968 | 1969-1970 | 12/19/77 |
|---|---|---|---|
| Ammonia (N) (mg/l) | | | 0.5 |
| Organic N (mg/l) | | | 5.5 |
| Nitrate (N) (mg/l) | | | 0.52 |
| Sulfate (mg/l) | | | 41.9 |
| COD | | | 1018 |
| Coliforms, Fecal (Colonies/100 ml) | | | 120 |
| Total Hardness (mg/l) | | | 208 |
| Total Alkalinity (mg/l) | | | 206 |
| pH | | | 7.6 |
| Secchi disk (m) | 0.3 | 0.22 | |
| Dissolved Oxygen (mg/l) | | | 3.2 |
| Conductivity (umhos/cm | | | 320 |
| Color (C.U.) | | | 160 |
| Solids, total (mg/l) | | | 1753 |
| Solids, suspended (mg/l) | | | 6878 |
| Turbidity (NTU) | | | 16 |
| Chorides (mg/l) | | | 33.1 |

Table 4. Composite Readings

| Measurement | 10-68 (1) | 1972-74 (2) | 1969-70 (3) | 12-19-77 (4) |
|---|---|---|---|---|
| Calcium (mg/l) | 25.1 | | 55.3 | |
| Manganese (mg/l) | | | 7.0 | |
| Sodium (mg/l) | 11.7 | | 14.33 | |
| Potassium (mg/l) | 2.9 | | 3.73 | |
| Magnesium (mg/l) | 14.7 | | 14.3 | |
| Turbidity, Unfiltered (NTU) | 27 | | | 11 |
| Color (Apha Pt-Co Units) | 30 | | | 100 |
| Specific Conductivity mho/cm | 330 | | 315 | 310 |
| Chlorophyll-A (mg/m$^3$) | 34.1 | 77 | 60.4 | |
| Sulfate (mg/l) | 10.2 | | 16.3 | 35.9 |
| Dissolved oxygen (mg/l) | 11.2 | 10.2 | 10.14 | 8.8 |
| pH | 9.5 | 9.05 | 8.85 | 7.7 |
| Total Alkalinity (as $CaCo_3$) mg/l | 126 | 145 | 140 | 179 |
| COD (mg/l) | 113 | 135 | 159 | 88 |
| Suspended solids (mg/l) | 43 | | | 27.5 |
| Total solids (mg/l) | | | | 432 |
| $NH_3$-N (mg/l) | 0.18 | 0.55 | 0.27 | 0.00 |
| Ortho $PO_4$ (mg/l) | 0.016 | 0.024 | 0.195 | 0.20 |
| Total P (mg/l) | 0.24 | 0.26 | 0.38 | 0.39 |
| $NO_3$ (N) (mg/l) | 0.09 | 0.12 | 0.15 | 0.22 |
| Total Organic N | 3.8 | 3.0 | 4.45 | |
| Particulate Organic N | | 1.65 | | 1.82 |
| Nitrite N (mg/l) | 0.004 | | | |
| $SiO_2$ (mg/l) | 6.4 | | | |
| Chloride | 21 | | 23.5 | 33.1 |
| Primary Productivity (mg C/l-hr) | 0.386 | | 0.337 | |
| Flouride (mg/l) | | | 0.41 | |
| Hardness (mg/l as $CaCo_3$) | | | | 237 |

(1) Composite samples from three stations.
(2) Average values for three stations, 12 times from Aug, 1972-March, 1974.
(3) From Brezonik and Shannon (1971)
(4) Two samples taken 2 ft below surface (Belanger op cit.)

Table 5. Miscellaneous Influent

| Measurement | Amount |
|---|---|
| SURFACE RUNOFF | Unknown |
| NITROGEN FIXATION BLUE-GREEN ALGAE | Unknown, estimate 20-80 lb/acre/yr |
| RECYCLING FROM SEDIMENT | Unknown |
| RAINFALL | |
| Ammonia (N) (mg/l) | 0.78 |
| Total N (mg/l) | 0.42 - 1.08 |
| Total P (mg/l) | 0.01, 0.08, 0.09 |
| MUNICIPAL WASTE | |
| Total N | 75 lb/day |
| Total P | 19 lb/day |
| INDUSTRIAL WASTE | |
| Total N | 192 lb/day |
| Total P | 9.6 lb/day |
| MUCK FARMS | |
| Total N | 1600 - 16,000 lb/day |
| Total P | 65 - 650 lb/day |
| CITRUS FARMS | |
| Total N | 4.54 - 33.4 mg/l |
| Total P | 1.4 - 52.9 mg/l |
| BEAUCLAIR CANAL (OUTFLOW) | |
| Total N | 2000 lb/day |
| Total P | 54-540 lb/day |
| SEEPAGE WELLS | |
| Nitrate-Nitrite (as N) (mg/l) | 2.7 - 30.6 |
| Phosphate (as P) (mg/l) | 1.4 - 52.9 |

Table 6. Approximate Total Phosphorus & Nitrogen Input (Kg/yr)

| Source | Total Phosphorus | Total Nitrogen |
|---|---|---|
| Private Housing | 3,146 | 12,417 |
| Winter Garden STP | 7,721 | 16,319 |
| Commercial | 1,589 | 31,788 |
| Muck Farms | 10,754 - 107,537 | 264,706 - 2,647,058 |
| Citrus Groves | 82,937 - 3,133,822 | 268,952 - 1,978,632 |
| Gourd Neck Spring | 3,743 | 74,859 |
| Storm Runoff | 9,437 | 82,780 |
| Direct Rainfall | 1,574 - 14,167 | 66,111 - 169,999 |
| Extraction from atmosphere by cyanophyta | ---- | 1,000,000 |
| Recycling from Sediment Approx. | 25,073 | 318,194 |
| TOTAL | 145,974 - 3,306,235 | 2,136,126 - 6,332,046 |

## 2.2 Physiology of Lake Apopka

### 2.2.1 Aquatic Macrophytes.

The most common aquatic macrophyte is water hyacinth, growing most profusely in the Gourd Neck Region. Drawdown will greatly stimulate the germination of this plant, along with many other plants, the seeds of which are found in abundance in the sediment (Table 7).

No submersed plants are present.

### 2.2.2 Algae.

"The computed productivity values for four dates in 1972-73...are within the range for some of the world's most productive systems during favorable periods...the metabolic activity of Lake Apopka is largely due to the activity of blue-green algae...productivity levels in Lake Apopka compared closely to values found in tropical East African lakes" (Fox, et al, 1977).

The four species of algae found by Fox, et al, Table 8, were cyanophyta (blue-green).

In general, the type of algae present and its density are an indicator of water quality. Yellow-green and yellow-brown algae tend to grow in oligitrophic waters, green algae in eutrophic waters, and blue-green algae in hypereutrophic, or highly polluted waters.

When blue-green algae thrive, a new polluting factor enters a lake. Blue-greens have the ability to extract nitrogen directly out of the atmosphere above the lake up to 80 pounds of nitrogen per-acre. It also extracts carbon dioxide out of the atmosphere. These plants then die and drop their newly-acquired load of pollutants into the lake bottom, often at a higher rate than it is entering from the watershed or other sources, and the eutrophication process is highly accelerated. Multiple inversion and Clean-Flo Lake Cleanser quickly reverse this process, and shift the trend backward from blue-greens toward greens in lesser and lesser densities.

Blue-green algae are often toxic to fish and other aquatic animal life, and can be very destructive to a lake and the animals living in or near it. One example is the many cases of cattle that have died drinking water with blue-green algae blooms.

We have repeatedly found in our research that noxious and nuisance blue-green algae blooms can be reduced or eliminated. As these plant species are circulated under water, they can no longer survive. This elimination has also been documented by Haynes, 1971, and Maleug, 1971.

Green algae growths can also be reduced as various water chemistry parameters such as pH and carbon dioxide concentrations are changed by aeration (Macbeth, 1973).

### 2.2.3 Bottom Sediment Analysis.

Bottom sediment depths in Lake Apopka range from zero to forty feet. The sediment is rich in nutrients (Table 10), and highly flocculent in nature. No definite sediment-water interface exists, and the muck freely mixes with overlying water (Fox, et al, 1977).

Bottom sediment is rich in nitrogen, phosphorus, and organic matter. The Clean-Flo Multiple Inversion process will cause the nitrogen to be discharged into the atmosphere through the bacterial conversion of nitrates and carbonaceous material into carbon dioxide and nitrogen gas. This is accomplished by pseudomonas, which is obligate, but capable of anaerobic respiration. At the anaerobic sediment surface nitrate serves as the oxidizing agent, or final electron acceptor. Pseudomonads use carbon from the sediment, and release nitrogen gas and carbon dioxide, which are exhausted to the atmosphere, and water. Ammonia will be converted to nitrate in the aerobic water.

As oxygen is brought to the bottom, and toxic gases removed, benthic organisms will begin to thrive on the bottom and feed on the muck. Thus, the deep organic bottom sediment layer will gradually be reduced to a thin firm bottom layer of inorganic matter somewhat resembling a clean, gritty sand-like texture, probably close to white or light gray or tan in color.

It is estimated that muck will be reduced from an average of five feet deep to less than one foot within five years, with many places showing a clean bottom, especially around the shoreline. More muck could possibly be removed during this period, however. (1)

Drawdown of Lake Apopka, however, will only reduce sediment depth by about seven inches (Fox, et al, 1971, p. 31).

This process of muck removal from lake bottoms is not new. It occurs regularly in nature when the spring and fall turnovers in northern lakes bring oxygenated waters down to the benthos (Odum, 1971). In addition, the activity of aerobic bacteria has been used to decompose sludge in waste treatment plants for many years (Wymore et al, 1968). The establishment of food webs is an integral part of ecological theory. By completing the food web bottom nutrients are recycled back into fish life (Fitzgerald, 1970 and Mortimer, 1941).

(1) Laing, R. L. Organic Muck Removal Through Multiple Inversion. Clean-Flo Laboratories, Inc. In-House paper. 12 PP.

During many of its lake restoration projects, Clean-Flo Laboratories has collected data that strongly supports this general theory of muck removal from the bottoms of eutrophic lakes. For the process to be successful, however, it has been found that highly efficient oxygenation of the bottom waters for an adequate period of time is necessary.

Ordinarily, long-term aeration of lake bottoms is an inefficient and expensive undertaking. Multiple inversion equipment developed and manufactured by Clean-Flo however, provides the necessary oxygenation at costs which are economically feasible.

### 2.2.4 Invertebrate Study.

The organisms found in 1962-1972 studies are forms which live at low levels of dissolved oxygen for extended periods of time. When these are the only benthic invertebrates found, oxygen stress is usually the cause. In 1977, no live organisms were found in the benthos (Table 11).

The presence of organic muck on the bottom of a natural lake indicates a deficiency of dissolved oxygen in the bottom waters. Organic muck is one by-product produced by anaerobic bacteria as they partially digest organic plant and animal matter which has dropped to the bottom. Other by-products of anaerobic digestion are noxious gases (hydrogen sulfide, methane and ammonia) and organic acids.

If the bottom waters of an eutrophic lake are oxygenated, the activity rate of anaerobic bacteria rapidly decline. Instead, aerobic bacteria thrive and begin feeding on the organic muck, or ooze, while iron and other sediments are oxidized (Mercier, 1955; Wirth et al, 1970; Irwin et al, 1966; Symons, 1970; Riddick, 1957). The by-products of aerobic digestion are water, carbon dioxide and ash. This results in a general improvement in water quality, as carbon dioxide is removed by aeration, and anerobic acids and gases are no longer produced (Macbeth, 1973 and Wirth et al, 1970).

Other types of benthos, or bottom-feeding organisms also take advantage of the newly oxygenated water and feed upon dead organic matter in the muck, as well as upon each other (Fast, 1971). These benthic organisms range from bacteria to insects and worms to crustaceans (Ruttner, 1963 and Linder et al, 1954). A food web is established, and bottom-feeding fish, including such game species as bass, move into deeper water and feed upon the smaller organisms. (Hooper et al, 1952; Irwin, 1967; Wirth et al, 1967). Eventually, most of the organic muck is removed from the bottom.

### 2.2.5 Fish Study.

"Flocculant deposits of dead phytoplankton are anaerobic, and do not afford a suitable habitat for benthic biota. Hence, forage fish seeking food and spawning grounds are restricted to the remaining productive zone around the perimeter. The Florida State Board of Health estimated the feeding and spawning grounds to be less than 2000 acres..." (Schneider, et al, 1969).

Quality of fish began declining before 1956, and has continued to the present (Table 12). Game fishing as a sport is now practically nonexistent.

Natural fish kills were reported in 1963 and 1971. Florida Game and Freshwater Fish Commission used Rotenone in 1957, 1958, and 1959 to kill shad.

Prior to 1956, Lake Apopka was noted for its size and variety of sport fish, and was acclaimed one of Florida's most popular freshwater fishing grounds (Federal Writers Project, 1939).

As the lake undergoes treatment, there will be changes in both water quality and habitat which can significantly affect the fish population.

It is probable that the following results will be achieved:

A- Maintenance of adequate oxygen levels for warm water fish throughout the water at all times of the year. This means an average dissolved oxygen content of at least 4 mg/l throughout the year. Many fish are highly susceptible to rapid changes in oxygen levels, and an oxygen smoothing effect will take place to eliminate this problem (McKee, et al, 1963; Fry, et al, 1946).

B- Quickly elimate noxious gases such as ammonia, hydrogen sulfide, methane, and carbon dioxide which are harmful to fish and other organisms in the water (Summerfelt, et al, 1967; McKee, et al, 1963; and Black, et al, 1954; Smith, et al, 1976; Broderius, et al, 1976; Sano, 1976; and Robinette, 1976).

C- Assuming that there is little or no oxygen at the lower level of the lake during a major part of the year, we will quickly enlarge the habitat available for the fish (Hooper, et al, 1952; Irwin, et al, 1967; Fast, 1971; and Johnson, 1966).

Livable habitat was shown by the study to be mainly the littoral region.

D- Under the same assumption, we should see a rapid increase in the amount of food available to the fish in their expanded habitat.

This food source will include the detritus now unavailable to bottom-feeding species which cannot forage during low bottom oxygen periods, and a vast increase in benthic organisms (Wirth et al, 1967; Fast, 1971; Ruttner, 1963; Linder, 1954; Fitzgerald, 1970; and Mortimer, 1941).

E- Make fish more tolerant of temperature. Ferguson compared temperature preference of several species of fish in lab tests with ideal water versus temperature preference gathered from several sources in field observations. In the case of field observations, lack of oxygen and excess noxious gases influence the results. Thus, the ideal lab conditions are much more closely identical to a Clean-Flo destratified lake. This study shows that the temperature preference in ideal laboratory water is 5.4-18°F higher than in field observations, which shows most species preferring 70-90°F water. Therefore, these species would survive in water several degrees warmer than natural preferred temperature (Ferguson, 1958).

Largemouth bass (Micropterus salmonoides) prefer lakes which contain aquatic vegetation and clear water. Turbidity is detrimental to growth and reproduction. Temperatures of about 80°F are most suitable. They become inactive in waters lower than 50°F, but survive in waters only slightly above freezing. Metabolism, food consumption and activity are positively correlated with temperatures up to 86°F. Suitable spawning temperatures seem to range from 60°F to 75°F. They begin spawning in the spring when water temperatures reach about 60°F.

Largemouth prefer bottom types of soft muck and organic debris, gravel, sand, or hard, non-flocculent clays. Adult bass mainly eat fish,but also take worms, mussels, frogs, crayfish, snails and large insects. Bluegill sunfish often are their principal food source during some months of the year.

For spawning, a substrate such as sand, gravel, roots or aquatic vegetation is required.

The Clean-Flo lake treatment program should have a positive effect upon largemouth in Lake Apopka, as it has in near-by Lakes Weston, Park and Maggiore. Turbidity in Apopka is often so high that is is unusable as habitat. A clearing of the water and small increase in littoral vegetation should expand available habitat, although little or no submergent macrophytes are present in Maggiore or Weston, and yet both lakes are now teaming with bass, whereas none could be found before the restoration programs began. Prevention of dense vegetation will eliminate escape cover for minnows and other forage fish such as bluegill. By returning benthic organisms to Lake Apopka to feed on bottom sediment, food available for bass will be vastly increased.

Spawning success should increase as the bottom substrate is cleaned of anaerobic sediment. It is well documented that bass eggs are very susceptible to the effects of wind and temperature, as are the fishes themselves. Black bass are very sensitive to changes in oxygen levels, a phenomenon which probably occurs drastically each night in Lake Apopka. Multiple inversion of the lake will tend to stabilize and smooth changes in water temperature, in winds, and in oxygen levels throughout the year.

The threadfin shad (Dorosoma petenense) is an excellent forage fish, often consumed by largemouth bass and catfish. They travel in schools and are frequently seen jumping about the surface. They feed selectively on plankton, benthos and organic debris.

Threadfin shad are delicate and require healthy water for maximum reproduction and growth. The Clean-Flo process should enhance their general habitat requirements, and they in turn will consume large amounts of organic sediment.

Bluegill (Lepomis macrochirus) prefer quiet, clear water with scattered beds of vegetation. They are among the most prolific warmwater game fishes and in lakes where there is little predation, their number can get out of hand resulting in extreme competition for food and stunted growth. They spawn in sand, gravel, dead leaves or mud. Zooplankton and aquatic insects are usually dominant foods, although plants are frequently eaten and sometimes dominate the diet.

Young-of-the-year survival in one study was positively correlated with the density of protective weed beds. Predation would not be necessarily bad, as it will tend to offset the bluegill's ordinarily high reproduction rates, reducing stunted bluegill and leaving older, larger bluegill which survive a hatch. Rapid growth will occur following multiple inversion due to a proliferation of benthic organisms.

Water temperatures between 60 and 80°F. are best for growth. They can survive temperature extremes from 36.5 to 92.8°F.

### 2.2.6 Microorganism Study.

After studying the bacteria in Lake Apopka, Thomas V. Belanger, Assistant Professor of Environmental Scineces, Florida Institute of Technology, Melbourne wrote:

"Total coliform counts were very high at the surface and indicate poor water quality. Other bacteriological tests were run in an attempt to determine the source of rashes received by divers in the lake. It appears that Staphlococcus may be the causative agent as it was found in tremendous numbers in both surface and two foot depth samples and has been cited as the source of various skin infections in the past." (Table 13).

Aeromonas was identified in connection with a kill of alligators, turtles and fish during the spring of 1971 (Fla Dept. Poll. Contr. 1971).

There are many bacteria found in natural waters, but it is important to remember that pathogenic species are not a part of the normal microbial populace of the water. Infectious species only contaminate water from some external source, almost invariably of fecal nature. Another important factor is that pathogenic bacteria do not multiply in natural waters, but are only in a transitory state (Volk, *et al*, 1973). Because of this, they are susceptible to the effects of multiple inversion. Multiple inversion tends to destroy pathogenic bacteria in several ways:

1- Most pathogenic bacteria are "strict anaerobes" (Frobisher, 1968). This means that oxygen is toxic to them, probably interfering with the ability of certain of their enzymes to transfer hydrogen. Multiple inversion saturates water with oxygen killing them directly. Bacteria which are not strict anaerobes and therefore not susceptible to oxygen toxicity are streptococcus, staphylococcus and salmonella, which are "facultative", which means that they have the faculty of surviving either in anoxic conditions, or in the presence of oxygen.

2- Pathogenic bacteria of the fecal type can survive in open water for a period of a few hours to a few weeks (Frobisher, 1968). In general, these bacteria require polluted water containing fecal material or urine to survive. Staphylococcus requires mucous material as a medium. Since multiple inversion quickly cycles pollutants into the aerobic food web, the survival time of fecal bacteria is greatly reduced (Fast, 1971).

3- Most pathogens require carbon dioxide, nitrogen, ammonia, phosphorus or sulphur to live (Frobisher, 1968; Niewolak _et al_, 1976). Aeration reduces the amount of these nutrients in the water (Wirth, _et al_, 1967).

4- Many pathogenic bacteria (and fungi) require an acidic to slightly acidic medium for survival, in the pH range of 5.0 to 8.0 (Frobisher, 1968). By removing carbon dioxide, which combines with water to make carbonic acid, and by killing acid-producing bacteria through step 1, multiple inversion causes water to become more alkaline, with pH tending to stabilize at about 8.4, making an unfavorable environment for most pathogenic bacteria. One particular exception to this trend is the vibrio that causes asiatic cholera, which prefers pH about 9.0.

5- Of all the bactericides ever made, the most effective, most universal bactericide is ultraviolet light. Practically all bacteria are quickly killed in the presence of ultraviolet light (Frobisher, 1968).

Ultraviolet light is emitted by the sun and is utilized to maximum advantage by multiple inversion. Multiple inversion gently gathers disease bacteria-bearing bottom waters into a central spot on the bottom, and carries it upward in a small column to the surface, without mixing it into the surrounding lake water. At the surface, it spreads out in a very thin sheet, about 0.1 inch thick, and moves across the upper surface of the water.(1) During this travel, it is irradiated by ultraviolet light, which weakens or kills the bacteria. Weakened cells can be photoreactivated by visual light or repaired in the dark by a process called excision repair. But the weakened bacteria are more susceptible to the affects of the other environmental changes produced by multiple inversion.

In summary, by aerating and circulating water, pathogenic bacteria are killed either by the toxic effect of oxygen, the lack of pollutant medium in aerated/circulated water, lack of carbon dioxide, lack of acid medium, or exposure to ultraviolet light, or any combination of these factors.

### 2.2.7 Watershed Analysis and Estimation of Water Retention Time.

The various sources of nutrient loading were not fully quantified in the references. The greatest source of loading appeared to be from the muck farms, which feed 0.05-0.5 lbs total nitrogen per acre into the lake per day, and 0.002-0.02 lbs total phosphorus per acre per day. Other sources appear

1- Laing, R. L. and S. R. Adams, Oxygen Transfer Constant ($K_L a$) for Clean-Flo Multiple Inversion Systems. Clean-Flo Laboratories, Inc. In-House Paper. PP. 2, 3.

to contribute significantly less. Nitrogen extracted from the atmosphere by blue-green algae is approximately 0.22 lbs/acre/day. Nutrients recycled from bottom sediment during periods of anaerobic conditions is probably in the range of 22 lbs N/acre and 1.8 lbs P/acre. (1)

While water retention time is generally considered to be 2.5 years (Schneider, et al, 1969), it is believed that evaporation rate was not considered, and that actual retention time is closer to 0.8 years (Table 14).

This information was used to develop the Vollenweider graph (Figure 5), and is more conservative than a 2.5 yr retention time. This graph, compared to the sources of phosphorus loading (Table 6) shows that no amount of nutrient diversion or drawdown could possibly have any significant influence on the trophic level of Lake Apopka.

(1) Taylor, R. B., Lake Wononscopomuc, Salisbury, Connecticut, May 16, 1978. Private Communication. Connecticut Dept. of Env. Protection.

Table 7. Aquatic Plant Seeds found in sediment (Chesnut and Barman, 1974).

| Aquatic Plant | |
|---|---|
| Water hyacinth | (Eichhornia crassipes) |
| | (Alternanthera philoxeroides) |
| Duckweed | (Lemna sp.) |
| Yellow water lily | (Nuphar advena) |
| Pickerelweed | (Pontederia cordata var. lanceolata) |
| Arrowhead | (Saggittaria lancifolia) |
| Arrowhead | (Saggittaria latifolia) |
| | (Panicum paludivagum) |
| | (Panicum hemitomon) |
| Bullrush | (Scirpus validus) |
| Cattail | (Typha domingensis) |
| Sawgrass | (Cladium jamaicensis) |
| Water pennywort | (Hydrocotyle umbellata) |
| Water Primrose | (Jussiaea michauxiana) |

Table 8. Algae Data

The following date on algae was obtained from Fox, et al, 1977.

| Species | Date | Type |
|---|---|---|
| Microcystis sp. | 1972-73 | cyanophyta |
| Lyngbya sp. | | cyanophyta |
| Oscillatoria sp. | | cyanophyta |
| Anabaena sp. | | cyanophyta |

Table 9. Sediment survey and analysis.

Muck samples were taken at test sites. Muck was speciated as follows:

| | |
|---|---|
| Organic ooze: | A soupy black fluid. |
| Organic muck: | Black, slippery, paste-like substance with no gritty particles |
| Inorganic silt: | Extremely fine, gritty substance usually looks like organic muck and often is mixed with organic muck. Inorganic silt portion does not burn off. |
| Peat: | Bits and pieces of undecomposed plant matter. |

| Test Site | Sediment |
|---|---|
| < 10% of sites | Peat |
| Top 3 feet, 90% of bottom | 500,000 lbs TN, 5-10,000,000 lbs TP |
| | 99% water, mostly organic muck |

Average depth of sediment: 5 feet

Sediment, percent water by weight: 95 (surface) -88 (3 feet)
by volume: 5 (surface) -12 (3 feet)

Percent volatile solids: 1.6 - 9.2

Percent ash weight: 3.4 - 2.8

Table 10. Sediment Chemistry, (Schneider, et al, 1969), 1m deep.

| Measurement | Average Value(mg/l) |
|---|---|
| Total phosphate (as P) | 8-12 wet, 200-2,000 dry, 5-10 x $10^6$ lbs |
| Ortho phosphate | 10 |
| Kjeldahl nitrogen | 2,000-37,000 wet, 11,000-43,000 dry |
| Nitrate/nitrite | 5-20 |
| Ammonia | 500-2,000 |
| Total nitrogen | 10,000-40,000 dry, 500 x $10^6$ lbs,<br>26,000 average, 200-2,000 wet |
| COD | 1,100,000 |

Table 11. Benthic Organisms

| Organism | Count per square foot |
|---|---|
| 1977 | |
| Viviparus georgianus altior pilsbry | dead shells - 150 acres |
| 1962-1969 (1) | |
| Sludgeworms (Oligochaeta) | - |
| Bloodworms (Chironomidae) | - |
| Phanton midges (order Diptera, family Culicidae) | |
| 1970-71 (2) | |
| Sludgeworms | - |
| Bloodworms | - |
| Phanton midges | - |
| Leeches (phylum Annelida, class Hirudinea) | (a few) |
| Scuds | (occassional) |
| Snails | (occassional) |
| Mayflies | 2 |

(1) Florida State Board of Health (undated report).

(2) Florida Technological University (1972), a one-year seasonal sampling (4 times) of about 30 stations.

Table 12. Fish Management History

| Date | Action Taken |
|---|---|
| 1946 | Dense Vallisneria uprooted by hurricane. |
| 1948 | Beauclair Canal opened to downstream lakes. |
| 1952 | Control structure installed in canal<br>Water hyacinths sprayed with herbicide. |
| 1956 | Florida Game & Freshwater Fish survey (gamefish essentially gone, 82% shad, 18% game fish) |
| Nov., 1957 | Rotenone for gizzard and threadfin shad removal. |
| Aug., 1958, Sept, 1959, | Rotenone. 20 million pounds shad killed. |
| May, 1963 | Fish-kill. 3 million pounds. |
| Spring, 1971 | Alligators, turtles, and fish killed in connection with Aeromonas organisms. |

Table 13. Microorganism Data

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Microorganism data was taken by Florida Institute of Technology on December 19, 1977.

A summary of the data follows:

| Microorganism | Count MPN/100 ml Surface | Count MPN/100 ml Two Feet |
|---|---|---|
| Total Coliforms (colonies/100 ml) | 6,250 | 410 |
| Fecal Streptococci (colonies/100 ml) | 380 | 105 |
| Staphylococci (colonies/100 ml) | 322,000 | 23,300 |

Table 14. Approximate Water Budget

| Influent | Million Gallons/yr |
|---|---|
| Spring | 14,162 |
| Direct Precipitation | 41,639.5 |
| Storm Runoff Citrus and Other | 13,349.7 |
| Winter Garden STP (1) | 255.5 |
| Storm Runoff, 18,000-Acre Muck Farms | 2,463.3 |
| Total Inflow | 71,870.0 MG/Yr |
| Beauclair Canal | (23,000.0) |
| Evaporation | (48,870.0) |
| | (71,870.0) |
| Lake Volume, MG | 58,650 |
| Retention Time, Years | 0.82 |

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(1) Marshall Robertson, Supt., Winter Garden Waste Treatment Plant.

# 3. PROPOSED ACTION AND ALTERNATIVES

## 3.1 Project Description.

Clean-Flo Laboratories, Inc. proposes a program for this lake similar to programs which have been successful in the restoration of lakes in the past. The process includes the following steps:

### 3.1.1 Feasibility Study.

The lake problems are analyzed and a feasibility study developed.

Pertinent water chemistry and physiological data are taken at several locations on the lake. These data are averaged and used for determining progress made on the lake, and for determining how the lake can be most efficiently and economically restored. Initial data has already been collected on the lake of this proposal.

### 3.1.2 Installation of Equipment.

A Clean-Flo Multiple Inversion System especially designed for maximum efficiency and economy in Lake Apopka is installed and maintained in working condition for a period of ten years.

### 3.1.3 Application of Clean-Flo Living Organisms.

Once the lake is conditioned by multiple inversion, nonpathogenic microorganisms are added to seed the lake with organic sediment-consuming benthos. This helps establish a food web from sediment to invertebrates to fish. The organisms also compete with plants and algae for phosphorus and nitrogen.

### 3.1.4 Continuous Lake Management.

Testing and evaluation of data, and maintenance and repair, if necessary, of equipment is continued. Continuous monitoring and analysis of water chemistry and physiology yields progress data and revisions necessary to the program to adjust for unforeseen events.

### 3.1.5 Periodic Water Quality Monitoring.

Water is tested at the beginning of each month, and a report sent to the customer.

### 3.1.6 Future Lake Maintenance.

The Clean-Flo Multiple Inversion System is maintained continuously in operating condition to keep the lake restored and handle incoming nutrients as they are carried in by rains and other nutrient sources.

Water quality monitoring is continued with periodic reports given to the customer, so that you are constantly aware of the quality of your water and any developing needs due to changing conditions.

## 3.2 Engineering Data.

### 3.2.1 The Clean-Flo Multiple Inversion System.

Oxygenation of bottom waters leads to a general increase in the oxidation state and a reduction in the concentrations of iron, manganese, nitrogen and sulfur (Irwin, _et al_, 1966), Wirth, _et al_, 1967, and Symonds, _et al_, (1970). These are all chemical elements which cause taste and odor problems in a given body of water.

As water is brought to the surface, it creates a laminar flow along the entire bottom toward each diffuser and up in a straight, central column to prevent the noxious or nutrient-rich bottom gases (Ammonia, methane, hydrogen sulide and carbon dioxide) from mixing with the main body of lake water. At the surface, it spreads out in a thin sheet to absorb oxygen from the atmosphere and to diffuse the bottom gases into the winds. This reduces nutrients available for the growth of aquatic weeds and algae, and removes gases toxic to fish.

Oxygen-laden surface waters will be brought down to the bottom to produce a favorable environment for fish and bottom-feeding benthic organisms, ranging from bacteria, to worms, larvae and crustaceans. The oxygenated water will oxidize iron and manganese, causing these trace nutrients to be precipitated. Oxygen at the bottom will kill the acid-producing anaerobic bacteria and enable calcium in the water to combine with phosphate and remain precipitated, instead of being redissolved by the acids.

As the benthic organisms feed on the muck, they will be assimilating the precipitated nutrients while decreasing the muck. Fish will feed on the benthic organisms. Thus nutrients in the water and muck are converted into food that stimulates healthy fish growth.

The type of multiple inversion system used and their locations are selected to secure maximum roll-over of the lake at a minimum cost without causing turbulence.

The multiple inversion system selected for Lake Apopka consists of 1456 oilless compressors sitting in 182 fiberglass cabinets on shore and floating stations with 2,912,000 ft weighted tubing going out to 2912 microporous ceramic diffusers on the lake bottom. The multiple inversion system will be maintained and kept in working condition by your Clean-Flo Service Agent for a period of ten years.

### 3.2.2 Application of Clean-Flo Living Organisms (C-FLO).

These organisms have been exempted from the need to be registered for use in lakes by the U.S. Environmental Protection Agency. They are acceptable to the U.S. Department of Agriculture for use in sewage and/or drain lines of establishments operating under federal meat, poultry, and egg product inspection programs.

Species include aerobacter (facultative), bacillus and nitrobacter (obligate), pseudomonas (obligate, but capable of anaerobic respiration), cellulomonas (cellulose utilizing), and rhodopseudomonas (requiring light only under anaerobic conditions). They have been injected full strength into the bloodstream of mice; and fed in the diet of chickens with no ill effects.

Reactions that are performed by the bacteria in C-FLO:

1- A. Anaerobic Respiration:

Fatty acids, for example, are converted to carbon dioxide using nitrate instead of oxygen, as the oxidizing agent or final electron acceptor. The nitrate is converted to nitrogen gas and water. The bacteria cannot use nitrate nitrogen for growth. They require ammonia or uric acid, and so the removal of nitrate means the removal of a nitrogen source for algae from the system. Anaerobic respiration is carried out by two species of pseudomonas in C-FLO.

B. Other nitrogen utilizing reactions:

Ammonia is oxidized to nitrite under aerobic conditions. The nitrite is further oxidized to nitrate by nitrobacter. The nitrate then serves as the final electron acceptor for the reactions in 1A. This cycle can provide for the substantial removal of nitrogen-containing compounds in a system.

2- Hydrogen sulfide is oxidized to sulfate aerobically. It may also be converted to sulfate through anaerobic respiration or through anaerobic photodecomposition by the rhodopseudomonas.

3- Carbohydrates are decomposed to sugars by the Bacillus and then most of the organisms, the Aerobacter and the pseudomonas, can oxidize the sugars to carbon dioxide.

4- Proteins are broken down to peptides and amino acids by the Bacillus and utilized for growth by most of the organisms present in C-FLO. Amino acids can be decomposed anaerobically but the products are putrid and therefore such organisms capable of the fermentation of amino acids have been eliminated from C-FLO.

5- BOD created from the anaerobic decomposition of fats, proteins, and carbohydrates is oxidized aerobically by the Bacillus and the pseudomonas. Thus the BOD is removed by oxidation. Suspended solids are removed to a large degree through the action of the enzymes secreted by the Bacillus. This creates BOD which is oxidized as mentioned previously.

After the Clean-Flo multiple inversion equipment has been installed, 35,208 gallons of C-FLO will be added. This will be added once a week for 3 applications. After these initial applications, this same quantity is to be added once a month for 3 applications.

### 3.3 Cost of the Proposed Action.

Project costs for the proposed action are $11,259,000. Costs will increase about 10% per year, due to inflation.

A summary of these costs is given in Table 15.

Table 15. Costs for The Restoration of Lake Apopka

| Item | Cost |
|---|---|
| Equipment, including cable | $ 5,618,000 |
| Offshore platforms | 112,000 |
| Labor | 433,000 |
| Electric Service | 910,000 |
| Maintenance, years 2 - 10 | 1,946,000 |
| Microorganisms | 986,000 |
| Shipping | 464,000 |
| Consulting & Studies (10 years), including travel | 240,000 |
| Contingencies | 550,000 |
|  | $ 11,259,000 |

### 3.4 Alternatives.

#### 3.4.1 Dredging.

Dredging would deepen the lake, but would not improve water quality so fish could survive.

At an estimated $1.25 per cubic yard, dredging would cost approximately $302,500,000, not including cost of procuring a spoils area, or $100,000,000 if only 33% of the lake is dredged, or the littoral region. This is considered to be economically unfeasible.

### 3.4.2 Drawdown

Dewatering the sediment will decrease sediment depth by 15%, at the most(Fox, et al, 1977).

Water quality will not be affected to any measureable degree, but almost certainly, the basin will fill with cattails(*Typha*) in the littoral regions, and with water hyacinth (*Eichornia crassipes*) in the remainder of the lake.

Drawdown, therefore will not achieve the desired goals of improving water quality for fish, or of reducing bottom sediment.

Cost of drawdown is $13,900,000, not including herbicides. At $300 per acre per year, herbicides would cost about $9,000,000 per year.

# 4. ENVIRONMENTAL IMPACTS

## 4.1 Climate

There will be no effect on climatic or meteorological factors resulting from multiple inversion, its construction or any portion of it. All changes will be in-lake, since multiple inversion is an in-lake process.

If drawdown is used, there is some speculation as to the temperature stabilizing effect of the lake for citrus crops. This risk has been dismissed because it was felt that temperature stabilization only occurs within 300 feet of the shoreline.

## 4.2 Air Quality

The proposed action will cause carbon dioxide and nitrogen gas to be exhausted to the atmosphere from the lake. It is doubtful that this is a measurable quantity, once mixed with the atmosphere. Since the atmosphere is 80% nitrogen, and 0.04% carbon dioxide, no harmful effect will result.

Initially, when the lake is rolled over, a detectable hydrogen sulfide odor will exist immediately over each diffuser boil. This will not be detectable 20 feet downwind of each diffuser. Hydrogen sulfide is presently being exhausted by the lake whenever natural inversion occurs, or during high winds.

The multiple inversion process will kill hydrogen sulfide-producing organisms so that within one to two years, $H_2S$ will drop to very low levels. Thus, while the initial effect will be the release of $H_2S$, ultimately the present $H_2S$ release will be stopped. After one or two years, then, air quality in the Lake Apopka vicinity will be improved over its present state.

The alternatives of drawdown or dredging would produce high levels of hydrogen sulfide release to the atmosphere, compared to multiple inversion. None of these factors have been measured.

### 4.3 Acoustics.

Air compressors totaling 728 horsepower will be used in the proposed action. These compressors will be placed in 70 land-based stations placed 1000 feet apart, and 112 floating stations placed 3000 feet apart.

Each station will produce 11 db noise, and will be audible at 22 feet distance.

No information was available for the dredging or drawdown alternatives. It is estimated that drawdown would use 1500 hp, located at one station. This may produce over 60 db, which may be audible at 7000 feet, and annoying at 6000 feet.

### 4.4 Water Quality.

Multiple inversion will improve water quality (Bateman, et al, 1977). Downstream water will be better than the present quality.

The alternative actions cannot improve water quality. Dredging would remove a source of nutrients, but this amount is about 9% of incoming nutrients. As the sediment is being pumped, considerable nutrients would be released. Drawdown of Lake Apopka will increase nutrient loading initially (Fox, et al, 1977). No long-term information is available.

Another potential risk to the environment due to drawdown may be from pumping pathogenic bacteria downstream. Staphococcus was found by Belanger to be as high as 320,000/100 ml.

### 4.5 Aquatic Biology.

In the proposed action, a food web will be reestablished in Lake Apopka. Incoming nutrients and bottom organic sediment will be cycled into the food web by an increase in benthic biota. Increased benthos and zooplankton will become food for fish. Fish growth and vigor will improve from the increase in invertebrates, and from stabilized oxygen and reduced hydrogen sulfide, ammonia, and carbon dioxide.

Drawdown or dredging would not affect the faunal life other than a temporary loss of whatever benthic organisms presently exist. While drawdown of other lakes have improved fishing and benthic forms, it cannot affect faunal life in Lake Apopka because the water quality in this lake will not change. This means that present hydrogen sulfide, ammonia, carbon dioxide, and dissolved oxygen levels will remain relatively unchanged.

### 4.6 Terrestrial Ecology.

The proposed action will increase waterfowl useage of the lake which may then increase their population in terrestrial areas.

The drawdown alternative will not affect terrestrial ecology.

Dredging, as an alternative would affect the flora and fauna of the spoils area. This could have either a negative or positive impact, depending on the amount of planning for the spoils area.

### 4.7 Socio Economics.

Lake Apopka was once known as one of the world's best fishing grounds. Today the fish are gone, and a single boat is seldom seen cruising the lake. In 1962, estimates were made that one acre-foot of water used for fishing and related activities adds $200 to $300 to the economy of a state, while an acre-foot of water used by agriculture adds only $50 (Wollman, et al, 1962). This amounts to about $9,000,000 per year at 1962 prices economic loss that Lake Apopka has suffered since 1950.

To bring fishing back to Lake Apopka, the lake must first be brought back to life. A food web must be reestablished. Only multiple inversion can accomplish this in Lake Apopka.

While equipment will be purchased from all over the United States, local labor will be used to install and maintain the multiple inversion equipment in Lake Apopka, at an expenditure of $433,000 for labor, and $1,946,000 for continuing maintenance over years 2 to 10. Local electricians will be hired at $910,000 to connect the electric service to the compressors. These prices include materials, much of which will be purchased locally.

Because the alternatives will not restore the lake for fish, no improvement of the economy will occur from fishing. If one of these alternatives were selected, money would be injected into the region from the labor used. This information was not available for this study.

# 5. ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD PROJECT BE IMPLEMENTED

5.1 With Construction of Project

a- An increase of acoustic levels of 11 db at 70 land-based stations and 112 floating stations.

b- Consumption of 728 hp 24 hours per day, 365 days per year.

c- Land useage. 100 square feet at each of 70 stations.

5.2 With Alternate Actions

a- Possible effect on spoils area with dredging.

b- Consumption of fuel for dredging power (figures not available).

c- Consumption of 1500 hp over a two-year period with drawdown. (Estimate).

d- Pumping of pathogenic bacteria into Lake Dora with drawdown.

5.3 With No Action

a- A loss of employment, tourist revenue of approximately $9,000,000 per year (1962 prices), and ensuing sociological and economic gains for the area.

b- The loss of a competitive position in the sport fishing market.

c- Continuation of sedimentation, deaths of aquatic fauna, and disease conditions.

## 6. MEASURES UNDER CONSIDERATION TO MINIMIZE UNAVOIDABLE ENVIRONMENTAL EFFECTS

a- Noise deadeners will be used in each compressor housing. This decreases noise from 23 db down to 11 db.

b- Power consumption will be reduced, once the desired goals are achieved.

## 7. THE RELATIONSHIP BETWEEN LOCAL SHORT TERM USES OF MAN'S ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG TERM PRODUCTIVITY

The implementation of the proposed project will assure optimum use of a major body of water for the United States. Although it will consume a relatively small amount of power for such an important use, the life expectancy of the restoration will be measured in hundreds of years and will provide recreation for tourists the world over, while bringing profitable fishing license income to the state of Florida, and service income to merchants on both a state-wide and local basis.

## 8. ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION, SHOULD IT BE IMPLEMENTED

Irretrievable commitments of this project are limited to the manpower expended in its construction; the material used, such as compressors, fiberglass, plastic hose, and electric cable and the energy used to operate the equipment. This energy, along with maintenance of the equipment, is an on-going expense, once the project is initiated.

## 9. REFERENCES

Bateman, J. M. and R. L. Laing, 1977. Restoration of water quality in Lake Weston, Orlando, Florida. J. of Aquatic Plant Management 15, pp 69-73.

Black, E. E. , E. J. Fry, and V. Black. 1954. The influence of $CO_2$ on the utilization of oxygen by some freshwater fish. Can. J. Zool. 32: 408-420.

Broderius, S. J. and Smith, L. L. Jr., 1976, Effect of hydrogen sulfide on fish and invertebrates: Part II- hydrogen sulfide determination and relationship between pH and sulfide toxicity. EPA-600/9-76-062b, U. S. Environmental Protection Agency, Duluth, Minn.

Fast, A. W. 1971a. The effects of artificial aeration on lake ecology. phD Thesis Michigan State University, East Lansing 566 P.

Fast, 1971b. The effects of artificial aeration on lake ecology. U. S. Environ. Prot. Agency. Water Pollution Control Res. Ser. 16010 EXE 12/71.

Federal Writers Project, 1939. Florida, a guide to southern most state. 600 P.

Ferguson, R. G. 1958. The preferred temperature of fish and their midsummer distribution in temperature lakes and streams. Canada Fisheries Research Board Journal 15:2 July-Nov. PP. 607-624.

Fillos, J., and H. Biswas, 1976. Phosphate release and sorption by Lake Mohegan sediments. Am. Soc. Civil Engr., J. Envir. Engr. Div., 2, 239.

Fitzgerald, G. 1970. Aerobic lake muds for the removal of phosphorus from lake waters. Limnol. Oceanogr. 15: 550-555.

Fox, J. L., P. L. Brezonik, and M. A. Keirn, 1977. Lake drawdown as a method of improving water quality. EPA 600/3-77-005, U.S. EPA, Corvalis, Ore. 94 p.

Frobisher, Martin, Sc.D. Fundamentals of Microbiology. W. B. Saunders Co., Philadelphia, 1968.

Fry, F. E., J. S. Hart, K. F. Walker, Lethal temperature relations for a sample of young speckled trout, University of Toronto Report, 1946.

Hasler, A. D., and W. G. Einsele, 1948. Fertilization for increasing productivity of natural inland waters, 13th No. Am. Wildlife Conf. Trans., PP. 527-555.

Haynes, R. 1971. Some ecological effects of artificial circulation on a small eutrophic New Hampshire Lake. phD. Thesis. Univ. N. H., DurHam, N. H. 165 pp.

Hephner, B. 1958. The effect of various fertilizers and the methods of their application on the fixation of phosphorus added to fish ponds, Bamidgeh 10 (1), 4-18.

Hooper, F. F., R. C. Ball, and H. A. Tanner. 1952. An experiment in the artificial circulation of a small Michigan lake. Trans. Am. Fish Soc. 82: 222-241.

Irwin, W. H., J. M. Symons, and G. G. Robeck, 1966. Impoundment distratification by mechanical pumping. J. Sanit Eng. Div., Proc. ASCE, 92(SA6): 21-40.

Irwin, W. J., J. M. Symons, and G. G. Robeck, 1967. Water quality in impoundments and modifications from destratification. PP. 130-152 in Symons, J. M. Ed. Water Quality Behavior in Reservoirs: A Compilation of Published Research Papers. U. S. Public Health Serv. Publ. No. 1390.

Johnson, R. S. 1966. The effect of artificial circulation on production of a thermally stratified lake. Wash. Dep. Fish. Fish. Res. Pap. 2(4): 5-15.

Kamp-Nielsen, L., 1975. Seasonal variation in sediment-water exchange of nutrient ions in Lake Esrom. Verh. Int. Verein, Limnol. (Ger.) 19, 1057.

Laing, R. L., and A. M. Adams, 1976. Organic muck removal through aeration/circulation. Clean-Flo Laboratories, Inc. Hopkins, Mn. 13 P.

Linder, C. H. and P. Mercier, 1954. Etude comparative de la repartition du zooplankton au lac de bret avant et apres aeration. Schweiz. Hydrol. 16(2): 309-317.

MacBeth, S. E. 1973. Some observations on changes in water chemistry and algal growth in artificially destratified lakes in Ontario. Paper Delivered at 36th Annual Meet. Am. Soc. Limnol. Oceanogr., June 1973, Salt Lake City, Utah.

Malueg, K., J. Tilstra, D. Schults, and C. F. Powers. 1971. The effect of induced aeration upon stratification and eutrophication processes in an Oregon farm pond. Presented at the Int. Symp. on Man-Made Lakes, Knoxville, Tennessee, May, 1971.

McKee, J. E. and H. W. Wolf. 1963. Water Quality Criteria. Calif. State Water Qual. Control Board Publ. 3-A (2nd Ed.). 548 PP.

Mercier, P. 1955. Evolution d'un lac eutrophic soumis a l' aeration artificielle sous-lacustre. Verh inter ver pmnol 12: 679-686.

Mortimer, C. H. 1941. The exchange of dissolved substances between mud and water in lakes. J. Ecol. 29: 280-329.

Neel, J.K., S. A. Peterson, and W. L. Smith. July, 1973. Weed harvest and lake nutrient dynamics, Proj. No. 16010 DFI, EPA-660/3-73-001, U.S. EPA, Corvalis, Oregon, 91 p.

Niewolak, S. and A. Korycka, 1976. Solubilization of basic slag by microorganisms in fertilized lakes. Polskie Archiwum Hydrobiol., 23, p. 25.

Odum, E. P. 1971. Fundamentals in Ecology. W. B. Saunders Co., Philadelphia, London, Toronto, PP. 27-33, 491-497.

Poon, C.P.C., and Sheih, J. M. S., 1976. Nutrient profiles of bay sediment. Jour. Water Poll. Contr. Fed., 48, 2007.

Riddick, T. M. 1957. Forced circulation of reservoir water yields multiple benefits at Ossiming, New York. Water and Sewage Works. 104(6): 231-237.

Ripl, W., 1976. Biochemical oxidation of polluted lake sediment with nitrate-a new restoration method. Ambio (Swed.), 5, 132.

Robinette, H. R. Effect of selected sub-lethal levels of ammonia on growth of channel catfish (Ictalurus punctatus). Progressive Fish-Culturist, 38, 26 (1976).

Ruttner, R. 1963. Fundamentals of Limnology. Univ. Toronto Press, Toronto. 295 P.

Sano, H., 1976. The role of pH on the acute toxicity of sulfite in water. Water Res. (G.B.), 10, 139.

Schneider, R. F. and J. A. Little, 1969. Characterization of bottom sediments and selected nitrogen and phosphorus sources in Lake Apopka, Florida. U. S. Dept of Int. Fed. Wat. Poll. Cont. Adm. S. E. Water Lab., Athens, Georgia. 65 P.

Serruya, C., 1975. Nitrogen and phosphorus balances and load-biomass relationships in Lake Kinneret (Israel). Verh. Internat. Verein. Limnol. (Ger.), 19, 1357.

Smith, L. L., Jr. and Oseid, D. M., 1975. Chronic effects of low levels of hydrogen sulfide on freshwater fish. Prog. Water Technol., (G.B.) 7, 599, 1976.

Smith, L. L., Jr. et al, 1976. Effect of hydrogen sulfide on fish and invertebrates: Part I-Acute and chronic toxicity studies. EPA-600/9-76-062a, U. S. Environmental Protection Agency, Duluth, Minn.

Summerfelt, R. C. and W. M. Lewis. 1967. Repulsion of green sunfish by certain chemicals. J. Water Pollut. Control Fed. 39(12): 2030-2038.

Symons, J. M., J. K. Carswell, and G. G. Robeck. 1970. Mixing of water supply reservoirs for quality control. J. Am. Water Works Assoc. 62(9): 322-334.

Viner, A. B., 1975. The sediments of Lake George (Uganda) II: Release of ammonia and phosphate from an undisturbed mud surface. Arch. Hydrobiol. (Ger.), 76, 368.

Vollenweider, R. A., 1969. Possibilities and limits of elementary models concerning the budget of substances in lakes. Arch. Hydroboil., 66:1-36.

Vollenweider, R. A., 1976. Advances in defining critical loading levels for phosphorus in lake eutrophication. Mem. First Ital. Idrobiol. (Ital.), 33, 53.

Volk, Wesley A. and Wheeler, Margaret F., Basic Microbiology. J. B. Lippincott Company, Philadelphia, 1973. PP. 268, 275.

Wirth, T. L. and R. C. Dunst 1967. Limnological changes resulting from artificial destratification and aeration of an impoundment. Wis. Cons. Dept. Research Report 22. 15 P.

Wirth, T. L. and R. D. Dunst, P. D. Uttormark, and Wm. Hilsenhoff. 1970. Manipulation of reservoir waters for improved quality and fish population response. Wis. Dept. of Natural Res., Research Report 62, Madison.

Wollman, N., R. L. Edgel, M. E. Farris, H. R. Stucky and A. J. Thomson, 1962. The value of water in alternative uses. Univ. New Mex. Press, 426 pp.

________________________________ 1971. Lake Apopka water quality improvement program. Florida Dept. of Poll. Contr. 29 p.

March 19, 1979

Mr. Robert L. Laing, President
Clean-Flo Laboratories
4342 Shady Oak Road
Hopkins, Minnesota 55343

Dear Mr. Laing:

Your feasibility study for the restoration of Lake Apopka through the Clean Flo method has been carefully reviewed by our technical staff. Enclosed are specific comments on various aspects of that study. Our major concern is that many of the statements in the proposal are based on undocumented data, especially with regard to reduction of the muck layer. Other statements conflict with the most recent information we have received through the limnological monitoring performed by Dr. Patrick Brezonik. We also feel that many of the project costs have been underestimated and that a ten-year restoration plan is not a realistic time frame.

As you are aware, the federal government places certain restrictions on funding lake restoration projects through the Clean Lakes program. Generally, funding is not available for the maintenance of lake aeration devices except when such procedures are a necessary preliminary part of other permanent restorative actions. In reviewing the Clean Flo proposal in relationship to this requirement, there does not seem to be a permanent restorative action. If the federal government interprets the proposal in a similar fashion, the full burden of implementing the project would then fall on the State of Florida. This would drastically affect the funding outlook.

If your proposal is to be considered seriously, the items of concern noted in this letter and in the enclosed comments must be addressed. We appreciate your interest in Lake Apopka, but this office remains of the opinion that the proposed drawdown represents the most potentially successful and cost-effective means of restoring Lake Apopka.

Sincerely,

SPW 3/20/79

A. Jean Tolman, Administrator
Water Resources Restoration
and Preservation

AJT:swm

cc: Rep. Everett Kelly
Archie Carr III

pg 1, ln 10-17

What is the source of your nutrient budget? Your findings differ considerably from Brezonik et al, 1978 (see references cited).

pg 2, ln 8

We are not aware that bottom sediments continue "to accumulate at an ever-increasing rate." Can you document this statement?

pg22, ln 9-11

No fish kills in Apopka or its downstream lakes have been attributed to ammonia or other naturally occurring toxic gases.

pg 2, ln 14-16

The estimate of nitrogen fixation for Lake Apopka by cyanophyta-and filamentous species is totally unreasonable. Please document. See Brezonik et al, 1978.

pg 2, ln 18-22

Bacterial concentrations in Lake Apopka generally remain within the levels for Class III waters. While Staphylococcus concentrations are generally not measured, this one sample data would seem to be an anomaly.

pg 3, ln 13-16

Toxic gases and low DO have not been at dangerous levels in the water column of Apopka.

pg 4, ln-6-10

The bottom waters of Lake Apopka are aerobic 95% of the time because the lake is so shallow and easily mixed by wind and wave action.

pg 4, ln 11-13

Keeping interstitial waters aerobic may reduce the release of phosphorus from deep lakes, but it will have a minimal effect in this shallow lake where advective movement of nutrients out of the sediments is important.

pg 5, ln 15-21

This system of diffusers and weighted tubing would also increase turbidity in the lake by disturbing the flocculent muck. Nutrients could be released by advective processes, and $CO_2$ and $N_2$ could increase through aeration. $N_2$ increases could cause fish kills (bends).

pg 5, ln 22 through pg 6, ln 2

Bacterial action would also cause release of P and N to the water column.

pg 6, ln 4-5

A 10-year project cannot be estimated at today's prices. Consideration must also be given to price increases, replacement costs, and inflation over the life of the project.

pg 6, ln 5-7

Herbicides cannot and will not beuused in a drawdown restoration.

pg 8, ln 1-2

This is only true in a P-limited system. Lake Apopka fluctuates between P and N limitation.

pg 8, ln 7-11

Phosphorus is primarily released to the water column by advective mixing of sediments, not through algal decomposition.

pg 8, ln 15-18

Improvement of nutrient status through an aerobic bottom has not been shown on Lake Apopka as the wording of this sentence seems to indicate.

pg 10, ln 16-22

Again, our nutrient budgets do not fully agree with yours. We need to see documentation of the extent of nitrogen fixation by cyanophyta. Also, nitrogen release from the bottom sediments has not been documented in previous drawdowns.

pg 10, ln 3-5

Fox et al show only an initial increase in orthophosphate and nitrate release from reflooded consolidated sediments. Nutrient levels actually decreased substantially over time. Drawdown, by keeping the sediments consolidated, will retard nutrient release over the long run.

pg 11, ln 1-2

Currently, ammonia levels pose no threat to fish populations.

pg 11, ln 15-18 and pg 11, ln 25 and pg 16, ln 9-11

These statements are not consistent with each other and detract from the accuracy of your assessment.

pg 12, ln 1

Here you state that Apopka often has pH levels greater than 10.0. Our data indicate that in Lake Apopka during 1977, pH ranged from 8.3 to 9.2 (Brezonik et al, 1978).

pg 15, Table 1

We feel that our most recent data from Brezonik et al (1978) are more reliable than your older data. These data show the following averages for ten stations:

ammonia nitrogen = 26.3 mg/l
ortho P = 1.07 mg/l

pg 17, Table 4

See additional current data from Brezonik et al (1978)

| | (lake-wide annual means) |
|---|---|
| calcium (mg/l) | 48.9 |
| sodium (mg/l) | 15.7 |
| potassium (mg/l) | 6.5 |
| magnesium (mg/l) | 19.6 |
| turbidity | 23.2 |
| color (cpu) | 72.7 |
| specific conductivity (umho/cm) | 414 |
| DO (mg/l) | 6.5 - 12.9 |
| pH | 8.87 |
| total alkalinity (mg/l) | 119 |
| $NH_3$-N (mg/l) | 0.040 |
| ortho-P (mg/l) | 0.047 |
| total P (mg/l) | 0.221 |
| $NO_3$ (mg/l) | 0.051 |
| total organic N | 3.4 |
| nitrite N (mg/l) | less than 0.01 |
| $SiO_2$ (mg/l) | 2.5 |
| primary prod. (mg C/hr) | 208 (gross)-140 (net) |
| hardness (mg/l as $CaCO_3$) | 203 |
| TOC (mg/l) | 47 |

Pg 18, Table 5

We find some data in this table difficult to believe. What is the source of this information?

Pg 19, Table 6

Again, we feel this information is not accurate. What is your source of data?

pg 20, ln 4-6

We have no reason to expect an extensive growth of hyacinths during the drawdown. We acknowledge that hyacinths multiply rapidly on a sand-substrate (FG&FWFC, 1978), but Lake Apopka would have very little exposed sandy bottom. As to rooted aquatic vegetation, we expect and welcome its germination and growth.

pg 21, ln 22-25 and pg 22, ln 1-6

The conversion of $NO_3$ to $N_2$ would occur only under anaerobic conditions which would supposedly not exist during the Clean-Flo aeration process.

pg 22, ln 8-11

Please document the total removal of all organic matter with only inorganic material left.

pg 23, ln 14

This statement is not true. See Brezonik et al (1978).

pg 25, ln 2-7

This would be irrelevant since oxygen depletion has not been a problem in Apopka.

pg 25, ln 17-18

What study are you referring to in this statement? It is normal for all lakes to have the littoral region as the main livable habitat.

pg 26, ln 1-12

This would be irrelevant since temperature tolerance of fish has not been a problem in Apopka.

pg 27, ln 3-13

Most fisheries biologists would agree that a healthy stand of rooted aquatic vegetation is required for a self-maintaining sports fishery. The proposal states that lakes that had aeration projects in the past (Lakes Weston and Maggiore) now support few, if any, submergent macrophytes. Although the proposal further states that the lakes are now teeming with bass, we feel that this could be an artificial and temporary situation.

We agree that a lack of vegetation "....will eliminate escape cover for minnows and other forage fish....," but we do not agree that this is beneficial. Under such conditions populations of prey items would quickly become depleted. In addition, young sports fish would also have no escape cover and would quickly be reduced in numbers through predation. The resultant fishery would consist of some large predators with few or no juveniles to replace those adults caught by fishermen.

pg 28, ln 1-4

Shad are currently doing quite well in Apopka. They generally dominate other species of fish in the lake by weight and/or number (FG&FWFC, 1977). Shad are generally thought of as a nuisance species and, as stated on page 24, lines 19-20 of your proposal, FG&FWFC conducted shad poisonings on Lake Apopka in 1957-59.

pg 28, ln 12-17

See comment, pg 27, ln 3-13.

pg 29, ln 5-6

Aeromonas was identified in virtually all lakes tested in South Florida (Wellings, Epidemiology Research Center, personal communication).

pg 29, ln 1-4 and ln 10-12

How did Staphylococcus reach such high levels without multiplying in the natural waters?

pg 30, ln 9-17

The pH level in Apopka averages 8.87 (Brezonik, et al 1978).

pg 31, ln 15 through pg 32, ln 12

This information is not consistent with our current material (Brezonik, et al 1978). Please document the nitrogen fixation levels and nutrient recycling from bottom sediments.

Attached are water and nutrient budgets for Lake Apopka from the Clean-Flo proposal, and from the referenced Brezonik study. The budgets in the Brezonik study are based on a large data set of monthly water quality parameter values for 1977. Lake Apopka's hydraulic retention time in Brezonik's study was 6.3 years, while the retention time in the Clean-Flo proposal was 0.8 years. Although evaporation is rarely included in the hydraulic retention time calculations, it was included in the Clean-Flo water budget. The Clean-Flo water retention time value actually suggests that there is a higher probability of a successful natural restoration of the lake once pollution abatement is instituted.

Significant discrepancies exist between the nutrient budgets of Clean-Flo and the Brezonik study. An example is the nitrogen and phosphorus fluxes due to the citrus industry. Clean-Flo values are approximately 10 times more than the values of Brezonik. The Clean-Flo values may represent nutrient loading before the citrus industry instituted pollution abatement measures, but are more likely due to unrealistic rates of nutrient loading from the citrus groves. The nitrogen fixation rate in the Clean-Flo proposal is extremely high. Under sufficient nitrogen conditions, very little nitrogen fixation occurs because it is energetically infeasible for the algae. Since large inputs of nitrogen presently enter the lake, very little nitrogen fixation would be expected. Disregarding sediment recycling, Clean-Flo nitrogen and phosphorus fluxes are 3-10 and 2-60 times more, respectively, than in Brezonik's study.

Although sediment nutrient recycling in shallow Lake Apopka makes the use of Vollenweider permissible nutrient loading models rather tenuous, both Clean-Flo and Brezonik used them for comparative purposes before and after pollution abatement. Differences in the nutrient and hydraulic data could explain inconsistencies between the Clean-Flo and Brezonik results; however, the shape of the delineations separating the eutrophic, mesotrophic, and oligotrophic levels were totally inaccurate in the Clean-Flo report.

pg 41, ln 12-15

What would be the status of recreational and commercial use of Lake Apopka during this 10-year period?

pg 42, ln 7-13

A more suitable restoration technique would return a lake to such a condition that the lake would be able to care for itself naturally (as it did before its crisis). This would not happen because the layer of calcium phosphate deposited on the bottom of the lake by aeration (page 22, lines 8-11) would redissolve upon cessation of aeration (page 12, lines 2-4). Also, the cost estimate for this continued maintenance was not included in the proposal.

pg 44, ln 17-21

This reaction only occurs during anaerobic conditions which would supposedly not exist during the Clean-Flo process.

pg 45, ln 12-14

BOD is the decomposition of organic material measured in the amount of oxygen used per ml of water. BOD is oxidation and is not removed by oxidation.

pg 46, Table 15

This cost estimate is inaccurate in that it does not reflect the true cost of the project. Since inflation will undoubtedly take place during the project, such increases should be calculated throughout the life of the 10-year restoration. The proposal states "costs will increase about 10% per year, due to inflation," but it is unclear whether or not these additional costs were included in the cost estimate.

pg 46, ln 18-19

We do not agree with the statement that dredging would not improve water quality. In the long run, dredging would improve water qualtiy by removing the loose sediments which are continuously stirred up by wind and wave action.

pg 47, ln 8

We do not agree that water quality would not be improved in the long run.

pg 47, ln 9-11

We do not agree that Typha is to be avoided, nor that hyacinths would take over the lake.

pg 47, ln 14-15

Herbicides would not be used in the proposed drawdown.

pg 48, ln 7-9

The risk of frost/freeze damage has not been dismissed. By maintaing one meter of water in the lake during the winter months and by scheduling the drawdown during the warmer months, the protective properties of the lake would remain substantially unchanged. (See appropriate section of Draft EIS for further explanation.)

pg 48, ln 14 through pg 49, ln 2

Why would drawdown or dredging release more $H_2S$ than aeration? In aeration, the release of $H_2S$ would last 1-2 years while in drawdown it would last less than 1 year.

pg 49, ln 9-12

This was addressed in the Draft EIS. Through the utilization of electric pumps in the more populated areas, the noise impact would be greatly reduced. Also, baffles could be constructed around the pump areas for further mitigation, if necessary.

pg 49, ln 13-20

It would seem that aeration would cause additional turbidity, at least initially, as water circulation increased. In addition, advective processes, promoted by aeration, would also increase nutrient levels in the water column.

pg 50, ln 8-17

These statements are not accurate. See Draft EIS.

pg 51, ln 19

Economic benefits, both from labor contracts and improved fishing benefits, are addressed in the Draft EIS (Appendix D).

## Literature Cited

Brezonik et al. 1978. Apopka Report (Report to Florida DER). Department of Engineering Sciences, University of Florida, Gainesville, Florida.

FG&FWFC. 1978. Oklawaha Basin Fisheries Investigation, Lake Carlton Rehabilitation Evaluation, F-30-5.

FG&FWFC. 1977. Study I. Upper Oklawaha Basin Fisheries Investigations, F-30, Final Report.

CLEAN-FLO LABORATORIES, INC.

4342 SHADY OAK ROAD HOPKINS, MINNESOTA 55343

April 3, 1979

Water Resources

Ms. A. Jean Tolman, Administrator
Water Resources Restoration and Preservation
Department of Environmental Regulation
State of Florida
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32301

Dear Ms. Tolman:

Thank you sincerely for your thorough review of our proposal to restore Lake Apopka. We especially appreciate your willingness to review alternate proposals such as ours after already working so hard toward a drawdown.

In this letter, I hope to respond to your satisfaction on all of the points you have raised, including documentation. We do know that while EPA welcomes innovative and alternative approaches to maintain an aerobic system above the bottom sediments, that presently they will not share maintenance or power costs. Accordingly, we will break the cost figures into initial costs and annual on-going costs. We have been advised through other proposals that if we can demonstrate on the basis of technical merit that there is a reasonable probability of success toward restoring Lake Apopka, then there is a strong possibility that the project would be eligible for consideration under the clean lakes program as an experimental project. This means that they would fund up to 90% of the initial costs, rather than 50%, if we can show them the innovativeness of multiple inversion in combination with bacteria on this major body of water, while tests on small lakes demonstrate its feasibility.

At the time our proposal was prepared, I was unaware that Brezonik, et al were in the process of presenting new information (1978) or that your EIS was completed. I would very much appreciate receiving copies of each of these, so that our proposal can be updated and resubmitted as expeditiously as possible. I estimate that once we have the materials, corrections can be made and our proposal can be resubmitted within three weeks. In the meantime, I am submitting the following preliminary response to the questions raised in your letter of March 19, 1979.

612/935-2137 To bring a lake back to life...You must first bring life back to the lake 800/3

Page 1, lines 10-17

The source of our nutrient budget was Schneider, et al, 1969, and Fox, et al, 1977, while muck farm data came from the Florida State Board of Health Report, 1965. Winter Garden STP input was obtained from Marshall Robertson, Supt., Winter Garden Waste Treatment Plant. This data will be updated to reflect Brezonik, et al, 1978 when it is received.

Page 2, line 8

We thought that it was common knowledge that sediment accumulation in lakes accelerates with age. For this reason we felt documentation was not necessary. Some references are: Orme, 1975; Sasseville, 1974; (Federal Highway Administration, 1973; Corps of Engineers, 1972; Olarn, 1971; Water Resources Council, 1970, 1971). References in parenthesis are digests or bibliographies of work being done on sedimentation, and contain well over 2,000 references, some of which give sedimentation rates. Due to our need to respond quickly to your review, we can provide more specific references at a later date, if you feel such a need.

Page 2, lines 9-11

While no fishkills have been attributed to ammonia in Lake Apopka, levels measured (i.e. 26.3 mg/l from Brezonik, et al, 1978) indicate that they probably have occured.

Ammonia levels ranging from 0.068 mg/l to over 3.58 mg/l can be toxic to fish (Mukherjee, et al, 1974; Rice, et al, 1975; Fromm, 1970; Burrows, 1964; Reichenbach-Klinke, 1967; Weil-Malherbe, 1962; Fromm, et al, 1968).

Hydrogen sulfide was not measured in Apopka Lake, but it is apparent from the other water chemistry that $H_2S$ is also critically high. $H_2S$ is harmful to fish at levels of 0.4 mg/l or higher (Broderius, et al, 1976; Smith, et al, 1975 and 1976). Multiple inversion, coupled with bacterial action converts $H_2S$ to harmless sulfates (Stanier, et al, 1976). Free $CO_2$ above 25 ppm can be lethal to fish. (Black, et al, 1954; Doudoroff, et al, 1950; Powers, et al, 1939).

Page 2, lines 14-16

Fox, et al, 1977 shows all phytoplankton to be blue-green (cyanophyta), including anabena sp., and microcystis sp.

Some species of blue-green algae such as anabena sp., aphanizomenon flos aquae, and microcystis aeruginosa can be toxic to mammals, birds, and fish (Prescott, 1951 and 1954).

Blue-green algae have the ability to extract up to 80 lbs per acre nitrogen from the atmosphere (De, 1939; Fogg, 1941; Fritsch et al, 1938; and Hutchison, 1944) or up to 2,480,000 lbs nitrogen per year in Lake Apopka. Carbon dioxide is also extracted in large quantities.

We have repeatedly found in our research that noxious and nuisance blue-green algae blooms can be reduced or eliminated. As these plant species are circulated under water, they can no longer survive. This elimination has also been documented by Haynes, 1971, and Maleug, 1971.

Green algae growths can also be reduced as various water chemistry parameters such as pH and carbon dioxide concentrations are changed by aeration (Macbeth, 1973).

Therefore, since green algae and other species except cyanophyta are incapable of extracting nitrogen from the atmosphere, it follows that up to 2,480,000 lbs of nitrogen can be prevented from entering Lake Apopka each year.

Page 2, lines 18-22

While this data, showing *Staphyloccocus* levels of 322,000/100 ml, may be an anomaly, it is well known that swimmers and divers have often acquired skin rashes from the water. *Staphylococcus aureus* causes impetigo, which may develop into carbuncles, boils, or other infections (Swatek, 1967). Because *Staphylococcus* causes pneumonia, further investigation appears to be warranted. If staph is found not to be the cause, it would seem that the real cause should be determined before this water is pumped downstream.

Page 3, lines 13-16

Ammonia has been as high as 26.3 mg/l (Brezonik, et al, 1978). Bottom values of hydrogen sulfide, carbon dioxide and dissolved oxygen are not known by me to have been measured (See comments above, Page 2, lines 9-11).

Page 4, lines 6-10

I have not seen data on bottom D.O., and therefore cannot respond directly to your statement. If the interstitial water is anaerobic 5% of the time, or 18 days out of the year, as your statement indicates, this is enough to kill the benthic organisms and release vast amounts of ammonia and phosphorus into the water column through anaerobic activity.

Mackenthun and McNabb, 1959 show a 94% decline in benthos population after temporary anaerobic benthic conditions. Lack of benthic invertebrates in Lake Apopka found by Fox et al, 1977 (p.46) is consistent with 18 days of anoxia in view of Mackenthun and McNabb.

Taylor (1) found nutrients recycled from bottom sediment in a mesotrophic Connecticut lake during periods of anaerobic conditions to be 3.3 times more nitrogen than all other influent sources, and 3.6 times more phosphorus. Terry (1974) found 51 to 171 mg ammonia released per kg of sediment per day when anaerobic conditions exist. With approximately $8 \times 10^9$ kilograms in the first three inches of sediment in Lake Apopka, this would amount to 850,000 to 2,850,000 lbs. per day ammonia released during anaerobic interstitial conditions. Sonzogni, et al (1977) measured a sediment release rate of 7 mg P/$m^2$-day for Lake Shagawa in Minnesota during two summer months. This would amount to 878,000 kg/day or 1,936,000 pounds P per day for Lake Apopka under similar conditions. Over an 18 day period, this would amount to 6.9 to 15.8 million kg/yr ammonia and 15.8 million kg/yr phosphorus released from the sediment. Schneider, et al, 1969, p. 23 estimates the top three feet of sediment in Lake Apopka to contain approximately 500 million pounds of nitrogen (all forms) and 5-10 million pounds of phosphorus.

Many other researchers have found large increases in ammonia and phosphorus during periods of anaerobic activity (Mortimer, 1941; Summerfelt, et al, 1967; McKee, et al, 1963; Black, et al, 1954; Fillos, et al, 1975; Robinette, 1976; Fekete, 1974; and Pamatmat, et al, 1973).

It has been shown that by maintaining aerobic conditions over lake bottom sediments in other lakes, the nutrient status of the lake can be improved (Fillos, et al, 1976; Serruya, 1975; Kamp-Nielson, 1975; Viner, 1975; Poon et al, 1976; Ripl, 1976; Fitzgerald, 1970; Mortimer, 1971; Nelson, et al, 1973; and Lynn, et al, 1972). While keeping the interstitial water aerobic prevents the release of nutrients, existing ammonia in the water can be converted to nitrogen gas through multiple inversion and bacterial action.

Page 4, lines 11-13

The above information for page 4, lines 6-10 should answer this question also.

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(1) Taylor, R. B., May 16, 1978. Lake Wononscupomuc, Salisbury, Connecticut. Connecticut Department of Environmental Protection. Private Communication.

Page 5, lines 15-21

It is normal to feel the diffusers would increase turbidity in the lake and release $CO_2$ and $N_2$. This is because aeration systems have such a reputation. It has not occurred, however, in lakes treated by Clean-Flo Multiple Inversion (See Bateman, et al, 1977 and St. Petersburg data on Lake Maggiore). Lake Apopka is very similar to Lake Maggiore, in which blue tilapia increased from 1½-lb average to 2 to 4 lbs each, black bass increased from minnows to 4 to 6 lbs, and "brim" from minnows to hand-sized over a two-year period. Bass and brim were not found in the lake prior to treatment. Fresh water shrimp, which were not found before, are now abundant. This will be documented in July of this year by an independent agency.

Page 5, lines 22 through Page 6, line 2

Bacteria feed on phosphorus and nitrogen in the water column, and in the bottom sediment, competing with aquatic plants for these nutrients. They would then be consumed by zooplankton, which would provide food for higher organisms, ultimately to become food for fishes. Our data always shows reductions in P and N in the water column under our program (e.g. Bateman, et al, 1977).

Page 6, lines 4-5

Price increases, replacement costs, and inflation were calculated in the 10-year project. As stated earlier, it will be broken down in the revised proposal.

Page 6, lines 5-7

It was my opinion that unless herbicides are used in a drawdown program, the lake will be unuseable for recreation purposes, with Typha growing as much as one-half mile from the shoreline, and heavy waterhyacinth or hydrilla growth throughout most of the remainder of the lake. This was only an opinion, based on the water quality of Lake Apopka, the results of the Lake Carlton drawdown, the Lake Lawne drawdown in Orlando, Lake Munson near Tallahassee, and the reports by Hestand, et al, 1974 and 1975. While herbicides cannot be funded by EPA, I felt that their possible need should be mentioned for the benefit of state and local funding agencies.

Page 8, lines 1-2

I will change this statement to show that Lake Apopka fluctuates between P and N limitation. Thank you for bringing this to my attention.

Page 8, lines 7-11

Subject to your approval, this sentence will be rewritten, per your comment, as follows: "This is released as algae die and decay on the bottom, providing phosphorus for new growth by advective mixing, and when the sediment-water interface becomes anaerobic."

Page 8, lines 15-18

This statement will be changed to show that improvement of nutrient status through an aerobic bottom has been shown on other lakes. Thank you for catching this semantic oversight.

Page 10, lines 16-22

This paragraph will be corrected according to the new data from Brezonik, et al, 1978. Nitrogen and phosphorus release from the Lake Apopka sediment has been documented by Fox, et al, 1977, pp. 77-79, in Lake Apopka. Documentation on other lakes was presented under my response to your comments on page 4, lines 6-10.

Nitrogen fixation by cyanophyta has now been documented (see corrections under Page 2, lines 14-16 above).

Page 10, lines 3-5

Nutrient levels over 150-180 days showed an increase in ortho-phosphate (p. 58), a decrease in total N (p. 60), and not much difference in the other parameters from the controls, in Fox, et al, 1977. This section will be revised when the Brezonik, et al, 1978 report is received. These tests did not simulate incoming nutrients however, and it is doubtful that retardation of nutrient release from the sediment will improve the quality of incoming water. Even according to the Brezonik, et al, 1978 data, nutrient loading must be reduced to improve water quality.

Water quality did not improve with simulated drawdown over time. It merely returned to about the same level as the controls. Any final differences between the drawdown tests and the controls in column and tank simulations were reversed in pool simulations. The controls were supposed to simulate Lake Apopka flushed with Gourd Neck spring water.

Page 11, lines 1-2

References were given above under "page 2, lines 9-11" showing Lake Apopka levels of ammonia to be an extreme threat to fish. The ammonia level will be changed from "10" to "26.3" mg/l, according to Brezonik, et al, 1978.

Page 11, lines 15-18 and Page 11, line 25 and Page 16, lines 9-11

Using Tillman's formula:

$$\mathrm{pH} = \log \left( \frac{\text{alkalinity} \times 0.203 \times 10^7}{\text{free } CO_2} \right)$$

where alkalinity (as $CaCO_3$) and $CO_2$ are in ppm (Newell, 19--), we get a daytime $CO_2$ value of 10 mg/l in Belanger's data, p. 16. Carbon dioxide increases each night, and declines each day due to plant respiration, causing each of these factors to cycle diurnally. The bicarbonate/carbonate forms of alkalinity have not been measured in this important process. Please explain the inconsistencies that you find in this assessment, and I will change it accordingly.

Page 12, line 1

We stated that pH levels were often greater than 10.0. This was an error on my part, and should be 9.0. Thank you for pointing this out. The text will be changed accordingly.

Page 15, table 1

Thank you for this information. I will add Ammonia (N) = 26.3 mg/l and Ortho P = 1.07 mg/l to this table (1978 data).

Page 17, table 4

Again, thank you for the Brezonik, et al, 1978 data, which will be added to this table.

Page 18, table 5

The references for the water chemistry tables were given on page 15. This was a poor format, and will be revised in the updated proposal to show references with each table. Table 5 data was from Schneider, et al, 1969 pp. 8, 31-34, D-6, except for nitrogen fixation which is an estimate from the references cited earlier (page 2, lines 14-16).

Page 19, table 6

Table 6 was taken from tables 5 and 14. It will be changed to Brezonik, et al, 1978 data when I receive it.

Page 20, lines 4-6

My response to your question to page 6, lines 5-7 applies here also. However, you have vastly more experience than I with the results of drawdown so I will modify this section to show that although you acknowledge that water hyacinths multiply rapidly on a sand-substrate (1350 acres, Schneider, et al, 1969 to 1550 acres, Fox, et al, 1977), you have no reason to expect an extensive growth during the drawdown. I will further indicate that you expect and welcome the germination and growth of rooted aquatic vegetation.

Page 21, lines 22-25 and Page 22, lines 1-6

Conversion of $NO_3$ to $N_2$ is unique to the Clean-Flo process. The interstitial water must be aerobic to oxidize ammonia to nitrate. The sediment must be low in oxygen, as you indicated, so that pseudomonas will act facultatively to use nitrate in place of oxygen as the final election acceptor, and carbon from the sediment, exhausting $CO_2$, $N_2$, and water. See Stanier, et al, 1976 pp. 724 and 595. $CO_2$ and $N_2$ are then exhausted to the air.

Page 22, lines 8-11

Organic sediment removal is documented by Laing, 1979.(2) Other documentation is forthcoming from several independent researchers, on this recent discovery for which patents are pending.

(2) Laing, R. L., 1979. Organic sediment removal through multiple inversion. Clean-Flo Laboratories, Inc., 15 pp. to be published.

Page 23, line 14

This information was taken from Fox, *et al*, 1977, page 46. However, only the northeast section of Lake Apopka was sampled. Very few benthic invertebrates were found in 30 stations in 1970-71. Those found are low-oxygen tolerant. I will correct this statement with Brezonik, *et al*, 1978 data, and add it to table 11.

Page 25, lines 2-7

The fact that no invertebrates were found in the northeastern section of Lake Apopka in 1977, and very few in the remainder of the lake in previous tests is an indication of severe recurrent oxygen depletions (Mackenthun, *et al*, 1959; Wangsness, 1977; Mackenthun, 1969).

Page 25, lines 17-18

Here, I was referring to Fox, *et al*, 1977, pages 45-46; the Florida Department of Pollution Control, 1972, Lake Apopka restoration project F.D.P.C. Tallahasee, Appendices B-1 to B-4; and the Florida State Board of Health, undated. Biological, chemical, and physical study of Lake Apopka, 1962-1964. Fla. State Board of Health, Jacksonville 56 + p.

It is only normal for highly eutrophic lakes to have only the littoral region as livable habitat, while the presence of organic sediment is an indication of lack of benthic life.

Page 26, lines 1-12

The purpose of this statement was to show that any increased temperature due to multiple inversion will not harm the fish.

Page 27, lines 3-13

Clean-Flo Laboratories, Inc. has been restoring lakes since 1971. All of these lakes are healthy fisheries. An example is Crystal Lake, Robbinsdale, Minnesota. This lake had a few stunted tullheads (*Ictalurus melas* R.) and goldfish (*Carassins auratus*) found only at the shoreline. Bottom ammonia was 20 mg/l, carbon dioxide 50 mg/l, hydrogen sulfide 4.8 mg/l, and dissolved oxygen 0 mg/l. In nineteen days, the lake was restored for fish, with bottom ammonia 0.2 mg/l, carbon dioxide 5 mg/l, hydrogen sulfide 0.0 mg/l, and dissolved oxygen 14 mg/l. The lake was stocked by Minnesota DNR with fingerling northern pike, bass, bluegill, and crappie, and today 20-25 lb northern pike are caught on a regular basis, with the other fish also thriving. Crystal Lake began with a dense aquatic macrophyte growth prior to restoration, and now it is sparse.

Such results are the rule in Clean-Flo restored lakes, and healthy fish in these lakes are no more temporary than results being reported on drawdown lakes. Yet, water quality remains much better than Lakes Tohopekaliga, Eola, Lawne, Munsun, and Carlton for instance, which were drawn down.

Your statement that lack of vegetation is beneficial would not be true in Lake Apopka, which has been practically devoid of submergent vegetation for years, and has an overpopulation of stunted shad, and lack of significant game fish.

In contrast, it is well-known that lakes filled with dense macrophyte growth often have an overpopulation of stunted fish (Snow, et al, 1970; Jenkins, et al, 1953; Bennet, 1962), and that dense aquatic macrophyte growth often follows drawdowns.

In Michigan are two lakes, ten miles apart. Houghton Lake has been an algae lake for at least fifty years, while Higgins Lake has been crystal clear (Secchi disk up to 250 feet) with aquatic macrophytes. Houghton Lake is well known for its excellent bass fishing, while Higgins Lake is well known for its lack of fish.

Thus it appears that dense macrophyte growth produces stunted fish; and that whether a lake has sparse vegetation or all algae is not as important as water quality and a good food web.

Page 28, lines 1-4

I agree that shad are doing quite well in Lake Apopka, and are generally thought of as a nuisance species. Although I alluded to it on page 27, lines 21-22, I failed to make clear that shad would be brought into a more controlled balance when the water is restored to encourage healthy bass growth. Then the shad will perform a very useful function of consuming bottom sediment, and will in turn become food for the bass. This section will be revised accordingly.

In contrast, previous fish management programs in Lake Apopka were only temporary, and harmful to the lake. Schneider, et al, 1969 states on page D-7, "...Trash fish poisoned and left to decompose...twenty million pounds of shad left to decompose in Lake Apopka (1957-1959) released 226,000 lbs of phosphorus."

Page 28, lines 12-17

The difference here is that the Clean-Flo program will encourage limited aquatic macrophyte growth, while drawdown will in all probability, due to the enormous influx of nutrients from outside sources plus the initial release of phosphorus and ammonia from the sediment, cause a severely dense aquatic macrophyte population, to such an extent as to cause stunted fish growth, and interfere with recreational use of the lake.

This statement will be amended to include shad, and to explain the necessity for balanced aquatic plant growth.

Page 29, lines 5-6

While common in lakes, the presence of Aeromonas of such an extent to produce a kill of cold-blooded vertebrates is an indicatation of Lake Apopka water quality (Stanier, et al, 1976, p. 618).

Page 29, lines 1-4 and lines 10-12

Staphylococcus, being a saphrophyte, lives on dead matter. It is an indication of Apopka water quality. My thesis here is that whether its presence is common, or it is a temporary invader, its levels can be reduced under the Clean-Flo program.

Page 30, lines 9-17

You are correct. Thank you for pointing this out. This statement will be amended to show that Lake Apopka water generally averages 8.87. It is interesting that when the high Staphylococcus levels were found, pH was 7.6 - 7.7. Dips in pH will occur diurnally. Bottom pH, when measured (but has not been measured in Lake Apopka), will almost invariably be found to be considerably lower than surface water. Thus, testing of the bottom waters of Lake Apopka is warranted.

Page 31, line 15 through Page 32, line 12

Nitrogen fixation levels have now been documented in our response to your questions, page 2, lines 14-16. Nutrient recycling from the sediment is documented in our response to your questions, page 4, lines 6-10.

Brezonik, et al, 1978, made an error in calculating hydraulic retention time. Dividing their estimated effluent by their estimated lake volume gives 1.12 years retention time, not 6.3. This low retention time is again indicative of the very high nutrient influx to the lake, which cannot be affected by drawdown.

The citrus grove data was taken from Schneider, et al, 1969, in which he indicated the need for more data. This section will be revised to show the new data.

I am having trouble understanding your statement that "since large inputs of nitrogen presently enter the lake, very little nitrogen fixation would be expected". I thought the two phenomena were independent. Nitrogen fixation can only occur from atmospheric $N_2$, not the forms predominantly flowing into the lake. Lehninger, 1975, page 366 writes, "the most self-sufficient cells known are the nitrogen-fixing photosynthetic blue-green algae...these organisms obtain their energy from sunlight, their carbon from carbon dioxide, their nitrogen from atmospheric nitrogen, and their electrons for reduction of carbon dioxide from water."

My Vollenweider curve was taken from the references given in the proposal, but these curves vary from reference to reference, the difference being that the mesotrophic range is given in some curves, while permissible loading is given in Brezonik's curve. Brezonik's lower line for permissible loading coincides approximately with my upper line which is generally felt to be where the mesotrophic range begins. Thus the difference between the graphs is not as great as it first appears. I will change our proposal to use the Brezonik, et al, 1978 data and Brezonik's Vollenweider curve, however.

Conclusions to be drawn from either graph are that drawdown will not significantly improve the quality of the lake, and that only by reducing incoming phosphorus to 61% of its present value, according to Brezonik, et al, 1978, can mesotrophic conditions be reached. This would require (using the 1978 data) eliminating all of the muck farm effluent including rain runoff; or eliminating all other sources, including rainfall, plus a portion of the muck farm loading. Either goal is unattainable. On the other hand in-lake improvement of water quality from multiple inversion has been amply demonstrated, because incoming nutrients are cycled into the food web.

Page 41, lines 12-15

Use of Lake Maggiore in St. Petersburg, Florida is an excellent example of the use that can be obtained in Apopka. After one year, the shoreline was muck-free clean, firm sand out for 50 feet. Today, after two years, it is clean, firm sand for 900 feet from the shoreline. 187,000 lbs of blue tilapia were harvested commercially last year. Water skiing has been continuous, and the lake now supports a great number of 4 to 6-lb bass, hand-sized brim, and freshwater shrimp which were not present before. No pre-treatment activities were interfered with, but quality of recreation has greatly increased. These same benefits can be expected on Lake Apopka, since the two lakes are almost identical in nature, except for size.

Page 42, lines 7-13

Our program for Lake Apopka is designed to last long enough to restore the lake, so that only a few of the original multiple inversion systems installed may be needed after that, depending upon the results of the studies, to handle incoming nutrients, and maintain an aerobic lake bottom. These nutrients will always continue to enter the lake, even if all sources except rainfall were stopped. Therefore, they must always be processed into the food web, unless at this time, winds can again keep the lake in balance.

The Lake Weston, Orlando, program was completed in two years. The system was removed, and after two additional years, has had no degradation of water quality. Fishing remains excellent, and I suspect that the nutrients are being removed through fish removal. Minnows are growing to replace those removed and to absorb more nutrients. Such results may also occur on Lake Apopka, but it is wise to plan on operating a few systems at minimal cost. This cost would probably be less than $50,000 per year, but cannot be determined until the lake is restored, and the new lake tested.

Page 44, lines 17-21

One of the many purposes of the Clean-Flo process would be to keep the interstitial waters aerobic so that anaerobic activity is reduced, thereby reducing the release of ammonia. The water is to be held aerobic so that ammonia is oxidized to nitrate. But the subsurface sediment will be at a low oxygen level, so that pseudomonas will use nitrate as the final electron acceptor and carbon from the sediment. Nitrogen gas and carbon dioxide are released, which are then exhausted to the atmosphere.

Page 45, lines 12-14

This terminology is often used but I will put it in the correct form that you suggest, when I rewrite the proposal.

Page 46, table 15

Lines 1 and 2 should have said that initial costs will increase about 10% per year. This will be corrected.

Table 15 will be rewritten to show initial costs in one column, and annual costs in another, as should have been done originally. Inflation after the program begins has been taken into consideration in the table, but delays in beginning the program will increase the prices shown in the table by about 10% per year.

Page 46, lines 18-19

This statement will be changed to your satisfaction. My opinion was that most of the nutrients feeding algae and suffocating game fish were coming from the incoming water, and that removing all of the sediment would not change this. With the new Brezonik, et al, 1978 data, nutrient release from the sediment has a much greater effect on water quality.

Page 47, Line 8

It is my opinion that with a drawdown without a major reduction of influent nutrients (which is unattainable) the lake will remain eutrophic, and will not support a healthy game fishery. However, I will change this statement to indicate your feeling that water quality would be eventually improved.

Page 47, lines 9-11

You have vastly more experience than we do in growth of aquatic macrophytes after drawdown. It was my opinion that Typha would grow out a considerable distance from the shoreline, and that hyacinth would germinate in some 1350 to 1550 acres of sandy area, and spread across the rest of the lake. If you have reason to believe that this will not occur, or that it will not interefere with recreation, and that it will improve lake quality, I will delete this statement from the proposal. Your comment does not seem to be consistent with the results found by Fox, et al, 1977, in which Typha and Eichornia sprouted in the dried sediment. Nor can these results be relied upon as conclusive, because they were not performed in situ. Considering the results with other drawdowns (e.g. Hestand, et al, 1975), and that Apopka has exceedingly poor water quality, I feel my statement is accurate. Therefore, I am wondering if you have other data which would support your position, of which I am unaware.

Page 47, lines 14-15

I understand that herbicide costs cannot be funded in a federal cost-sharing program. I do feel that it will be needed, however with a drawdown, much more so than it was needed at Lake Carlton, and therefore, its cost should be considered as a possible expense to be borne entirely by state and local agencies, should it be necessary. I can modify this statement to reflect your anticipated no-action if you so desire.

Page 48, lines 7-9

The material I received did not indicate that the drawdown would take place only during the warmer months. Fox, et al, 1977, page 12 estimated 3 concurrent fiscal years as the project length. The proposal will be changed according to this new information.

Page 48, line 14 through Page 49, line 2

In a drawdown, a large area of sediment would be exposed. This would release more $H_2S$ than the small amount released with multiple inversion. You are right about the duration of release, however, and this will be incorporated into the proposal.

Page 49, lines 9-12

I would appreciate receiving a copy of the EIS, so that a more accurate statement could be made. Was the cost of baffles figured in the drawdown EIS? This, and any other information you could give me will be added to your proposal. It was not my intention to write an EIS for you, but rather to give you guidelines for writing one, should you decide to change to our program for restoring the lake.

Page 49, lines 13-20

The feeling that "aeration" increases turbidity and nutrient levels is common because of turbulence created by other systems. The Clean-Flo Multiple Inversion System, however, gently entrains bottom water without lifting the flocculant sediment. In all lakes tested, turbidity and nutrient levels have decreased under the Clean-Flo program. See Bateman, et al, 1977; Laing, et al, 1975; (3) Laing, 1974.

Page 50, lines 8-17 and Page 51, line 19

I would appreciate seeing your EIS on drawdown, so that a more accurate statement can be made, or hopefully, we could work together on it.

I hope this has answered your questions satisfactorily until we have an opportunity to revise the proposal with the new data. While the new data shows nutrient loading to be not as severe as the original data indicated, the conclusions are not significantly altered, but it does indicate that we can have even better results. Major considerations in the restoration project should be as follows:

| | | |
|---|---|---|
| 1- | Multiple inversion will prevent release of N and P from sediment. | Drawdown will cause an initial release of N and P, followed by an improvement approximating controls. |
| 2- | The Clean-Flo process will continuously cycle incoming nutrients into the food web, causing an improvement in water quality. | Any beneficial long-term effect of drawdown on nutrients will probably be negated by incoming pollutants. |
| 3- | At least five feet of sediment will be converted to aquatic fauna over a ten-year period through the Clean-Flo program, regardless of water depth. This would leave a clean, firm bottom under approximately 50% of the lake. | Compaction by drawdown will be about 10% in the sediment existing from 66.5 ft MSL to 58 ft MSL. This would amount to 3 inches compaction over approximately 50% of the lake. |

---

(3) Laing, R. L. and A. M. Adams, 1975. A study of the efficacy of Clean-Flo Lake Cleanser in controlling aquatic plants in three Minnesota aerated lakes. Clean-Flo Laboratories, Inc. In-house paper. 67 + pp.

| | | |
|---|---|---|
| 4- | Quality of fish will be improved through ridding the lake of hydrogen sulfide, ammonia, and carbon dioxide, and by establishing a benthic food web, with the Clean-Flo system. | Improvement of fishing definitely resulted from drawdowns on other lakes. High nutrient influx on Lake Apopka will continue to feed aquatic plants, which in turn, will die and settle on the bottom. It is my opinion that during anaerobic periods, ammonia, hydrogen sulfide and carbon dioxide will continue to be released. Coupled with low oxygen, fish stress will continue. |
| 5- | Clean-Flo presents no deleterious effects on the environment. | The cause of frequent skin rashes should be investigated prior to drawdown. |

Thank you again for your kind consideration. I am most anxious to see your response.

Best regards,

Robert L Laing

Robert L. Laing, President
CLEAN-FLO LABORATORIES, INC.

RLL:ak

## ADDITIONAL REFERENCES CITED

Bateman, J. M. and R. L. Laing, 1977. Restoration of water quality in Lake Weston, Orlando, Florida. J. of Aquatic Plant Management 15, pp 69-73.

Bennett, George W.,

1962. Management of artificial lakes and ponds. New York, Rheinhold Publ. Corp., 283 pp.

Black, E. E., E. J. Fry, and V. Black, 1954. The influence of $CO_2$ on the utilization of oxygen by some freshwater fish. Can. J. Zool. 32: 408-420.

Broderius, S. J. and Smith, L. L. Jr., 1976, Effect of hydrogen sulfide on fish and invertebrates: Part II-hydrogen sulfide determination and relationship between pH and sulfide toxicity. EPA-600/9-76-062b, U. S. Environmental Protection Agency, Duluth, Minn.

Burrows, R. E. (1964) Effects of accumulated excretory products on hatchery-reared salmonids. U. S. Dept. of Interior, Bureau of Sport Fisheries & Wildlife Research Report 66: 1-11.

Corps of Engineers, 1972. Notes on Sedimentation Activities, Calendar Year 1972. Water Resources Council, Washington, D.C. Committee on Sedimentation, 298 pp.

De, P. K. 1939. The role of blue-green algae in nitrogen fixation in rice fields. Proc. Roy. Soc. London (b), 127: 121-139.

Doudoroff, P., and Katz, M., 1950. Critical review of literature on the toxicity of industrial wastes and their components to fish. Sewage Ind. Wastes 22(11), 1432-1458.

Fast, A. W. 1971a. The effects of artificial aeration on lake ecology. phD Thesis Michigan State University, East Lansing 566pp.

Fast, 1971b. The effects of artificial aeration on lake ecology. W. S. Environ. Prot. Agency. Water Pollution Control Res. Ser. 16010 EXE 12/71.

Federal Highway Administration, Washington, D. C., 1973. Notes on Sedimentation Activities, Calendar Year 1973, Water Resources Council, Washington, D. C. Committee on Sedimentation, 308pp.

Fekete, Andras, Master's thesis, 2 Oct., 1973. The release of phosphorus from pond sediments and its availability to lemna minor L. Rutgers, The State Univ., New Brunswick, N. J. Dept of Soils and Crops. Office of Water Research and Technology, Washington, D. C., 99 pp.

Fillos, J., and Swanson, W. R., 1975. The release rate of nutrients from river and lake sediments. Jour. Water Poll. Control Fed., 47, 1033.

Fillos, J. and H. Biswas, 1976. Phosphate release and sorption by Lake Mohegan sediments. Am. Soc. Civil Engr., J. Envir. Engr. Div., 2, p 239.

Fitzgerald, G. 1970. Aerobic lake muds for the removal of phosphorus from lake waters. Limnol. Oceanogr. 15: pp 550-555.

Fogg, G. E. 1942. Studies on nitrogen fixation by blue-green algae. I. Nitrogen fixation by Anabaena cylindricum Lemm. Jour. Exper. Biol., 19: 78-87.

Fritsch, F. E., and De, P. K. 1938. Nitrogen fixation by blue-green algae. Nature, 142: 878.

Fromm, P. O., and J. R. Gillette. (1968) Effect of ambient ammonia levels on blood ammonia and ammonia excretion by trout. Comp. Biochem. Physiol. 26: 887-896.

Dr. Paul O. Fromm, Professor, 1970. Toxic action of water soluble pollutants on freshwater Fish. Department of Physiology, Michigan State University East Lansing, Michigan 48823 for the Water Quality Office Environmental Protection Agency Grant Number 18050 DST.

Haynes, R. 1971. Some ecological effects of artificial circulation on a small eutrophic New Hampshire Lake. phD. Thesis. Univ. N. H., Durham, N. H. 165 pp.

R. S. Hestand and C. C. Carter, 1974. The effects of a winter drawdown on aquatic vegetation in a shallow water reservoir. Reprinted from Hyacinth Control Journal Volume 12, May 1974, pp. 9-11.

R. S. Hestand and C. C. Carter, 1975. Succession of aquatic vegetation in Lake Ocklawaha two growing seasons following a winter drawdown. Hyacinth Control Journal Volume 13, June 1975, pp. 43-47.

Hutchinson, G. Evelyn. 1944. Limnological studies in Connecticut. VII. A critical examination of the supposed relationship between phytoplankton periodicity and chemical changes in lake waters. Ecology, 25: 3-26.

Jenkins, Robert M., and Gordon E. Hall
1953. The influence of size, age, and condition of waters on the growth of largemouth bass in Oklahoma. Okla. Fish. Res. Lab., Rept. no. 30 43 pp.

Kamp-Nielsen, L., 1975. Seasonal variation in sediment-water exchange of nutrient ions in Lake Esrom. Verh. Int. Verein, Limnol. (Ger.) 19, 1057.

Laing, R. L. 1974. A non-toxic lake management program. Hyacinth Control Journal 12:41-43.

Albert L. Lehninger, 1975. Biochemistry. The Molecular Basis of Cell Structure and Function. The Johns Hopkins University School of Medicine. Worth Publishers, Inc., N. Y., 1104 pp.

Lynn, R. I., Murray, R. B., 1972. Water quality of Hyrun Lake and its relationship to algal blooms. Utah Water Research Lab., Logan. (405 725), 75 pp.

Mackenthun, K. M. and C. D. McNabb. 1959. Sewage stabilization ponds in Wisconsin, Wis. Committee on Water Poll., Madison Bull. No. WP105, 1-52.

Kenneth M. Mackenthun, 1969. The Practice of Water Pollution Biology. United States Department of the Interior Federal Water Pollution Control Administration Division of Technical Support.

Malueg, L., J. Tilstra, D. Schults, and C. F. Powers. 1971. The effect of induced aeration upon stratification and euthrophication processes in an Oregon farm pond. Presented at the Int. Symp. on Man-Made Lakes, Knoxville, Tennessee, May, 1971.

McKee, J. E. and H. W. Wolf. 1963. Water Quality Criteria. Calif. State Water Qual. Control Board Publ. 3-A (2nd Ed.). 548 pp.

Mortimer, C. H. 1941. The exchange of dissolved substances between mud and water in lakes. J. Ecol. 29: 280-329.

Mortimer, C. H. 1971. Chemical exchanges between sediments and water in the Great Lakes - speculations on probable regulatory mechanisms. Limnol. Oceangr. 16: 387-404.

Mukherjee, S., and Bhattacharya, S., 1974. Effect of some industrial pollutants on fish brain cholinesterase activity. Environ. Physiol. Biochem. (Den.), 4, 226.

Nelson, D. W., L. B. Owens, and R. E. Terry. 1973. Denitrification as a pathway for nitrate removal in aquatic systems. Purdue Univ., Lafayette, Ind. Water Resources Research Center. 93 pp.

Newell, 19--. J. of Am. Waterworks Ass'n., Vol. 24, No. 4, p. 561.

Olaru, Hanu, 1971. Sedimentation: Annotated Bibliography of Foreign Literature, 1969-1970 Survey No. 7. National Science Foundation, Washington, D. C. Special Foreign Currency Science Information Program. Rept No: SFCSI-AGR (TT-71-50005), 343 pp.

Orme, Antony R., 1975. Ecologic Stress in a Subtropical Coastal Lagoon: Lake St. Lucia, Zululand California Univ Los Angelses Dept of Geography (072265). Pub. in Geoscience and Man, v12 p9-22, 20 June 75.

Pamatmat, Mario M., R. Stephen Jones, Herbert Sanborn, and Ashok Bhaqwat, Sept. 1973. Oxidation of organic matter in sediments. Washington Univ., Seattle Dept. of Oceanography. (370-280), 116 pp.

Poon, C. P. C., and Sheih, J. M. S., 1976. Nutrient profiles of bay sediment. Jour. Water Poll. Contr. Fed., 48, 2007.

Powers, E. B., Shields, A. R., and Hickman, M. E., 1939. The mortality of fishes in Norris Lake. J. Tenn. Acad. Sci. 14(2), 239-260.

Prescott, G. W., 1951. Algae of the western great lakes area. Wm. C. Brown Company Publishers, Dubuque, Iowa, 977 pp.

Prescott, G. W., 1954. The freshwater algae. Wm. C. Brown Company Publishers, Dubuque, Iowa, 348 pp.

Reichenbach-Klinke Von H. H. (1967) Untersuchungen uber die Einwirkung des Ammoniakgehalts auf den Fischorganismus. Arch. Fischereiwiss. 17: 122-132.

Rice, S. D., and Stokes, R. M., 1975. Acute toxicity of ammonia to several developmental stages of rainbow trout. Salmo Gairdneri. Fish. Bull., 73, 207.

Ripl, W., 1976. Biochemical oxidation of polluted lake sediment with nitrate-a new restoration method. Ambio (Swed.), 5, 132.

Robinette, H. R., Effect of selected sub-lethal levels of ammonia on growth of channel catfish (Ictalurus punctatus). Progressive Fish-Culturist, 38, 26 (1976).

Sasseville, Dennis R., 1974. Present and Historic Geochemical Relationships in Four Maine Lakes. Maine Univ., Orono. Dept. of Geological Sciences. Office of Water Research and Technology, Washington, D. C., 69 pp.

Serruya, C., 1975. Nitrogen and phosphorus balances and loadbiomass relationships in Lake Kinneret (Israel). Verh. Internat. Verein. Limnol. (Ger.), 19, 1357.

Smith, L. L., Jr. and Oseid, D. M., 1975. Chronic effects of low levels of hydrogen sulfide on freshwater fish. Prog. Water Technol., (G.B.) 7, 599, 1976.

Smith, L. L., Jr. et al, 1976. Effect of hydrogen sulfide on fish and invertebrates; Part I-Acute and Chronic toxicity studies. EPA-600/9-76-062a, U. S. Environmental Protection Agency, Duluth, Minn.

Howard Snow, Arthur Ensign and John Klingbiel, 1970. The Bluegill, Its Life History, Ecology and Management, Publication 230-70.

Sonzogni, W. C., D. P. Larsen, K. W. Malueg and M. D. Schuldt, 1977. Use of large submerged chambers to measure sediment-water interactions, Water Res. 11:461-464.

Stanier, R. Y., E. A. Adelberg, and J. L. Ingram, 1976. The microbial world. Prentice-Hall, Inc., New Jersey, p. 553.

Summerfelt, R. C. and W. M. Lewis. 1967. Repulsion of green sunfish by certain chemicals. J. Water Pollut. Control Fed. 39(12): 2030-2038.

Swatek, Frank E. 1967. Textbook of Microbiology. The C. V. Mosby Company, St. Louis, 721 pp.

Terry, R. E., May 1974. Denitrification in Indiana Lake, Reservoir, and Pond Sediments. Purdue Univ., Lafayette, Ind. Office of Water Research and Technology, Washington, D. C. (291 650), 83 pp.

Viner, A. B., 1975. The sediments of Lake George (Uganda) II: Release of ammonia and phosphate from an undisturbed mud surface. Arch. Hydrobiol. (Ger.), 76, 368.

Wangsness, David J., 1977. Physical, Chemical, and Biclogical Relations of Four Ponds in the Hidden Water Creek Strip-Mine Area, Powder River Basin, Wycming Geological Survey, Cheyenne, Syo. Water Resources Div. 48 pp.

Water Resources Council, Washington, D. C., 1970. Annotated Bibliography on Hydrology and Sedimentation 1966-1968. United States and Canada Joint Hydrology-Sedimentation Bulletin No. 10. 625 pp.

Water Resources Council, Washington, D. C., 1971. Notes on Sedimentation Activities, Calendar Year 1971, Rept. NO: US-WRC-0100, 254 pp.

Weil-Malherbe, H. (1962) Ammonia metabolism in the brain. In Neurochemistry (Edited by Elliot, Page and Quastel), pp. 321-329.

Wirth, R. L. and R. D. Dunst, P. D. Uttormark, and Wm. Hilsenhoff. 1970. Manipulation of reservoir waters for improved quality and fish population response. Wis. Dept. of Natural Res., Research Report 62, Madison.

Wollman, R., R. L. Edgel, M. E. Farris, H. R. Stucky and A. J. Thomson, 1962. The value of water in alternative uses. Univ. New Mex. Press, 426 pp.

DER Response to Clean-Flo

A general discussion of aeration and its potential for restoring Lake Apopka can be found in Section 3. The following responses are in answer to major points of contention between DER and Clean Flo, Inc., in the latter's restoration proposal:

1. Aerobic vs anaerobic conditions in Lake Apopka. Clean Flo, Inc., feels that the high levels of ammonia reported (26.3 mg $l^{-1}$) for Lake Apopka indicate highly anaerobic conditions which are harmful to fish and other organisms. However, the values quoted in the Clean Flo proposal are interstitial ammonia levels. The actual concentrations of ammonia in the water column of Lake Apopka are less than 0.20 mg/l (Brezonik et al 1978). In addition, dissolved oxygen levels are saturated or supersaturated (7-15 mg/l). Lake Apopka is quite shallow and undergoes extensive wind mixing. This keeps the water and upper layer of the sediment well oxygenated. The problem in Lake Apopka is not one of anoxic conditions.

2. Nitrogen fixation in Lake Apopka. Several factors affect nitrogen fixation rates. A large amount of energy is required to convert nitrogen gas to organic nitrogen. In order for an organism to compete successfully in a given environment, it must be able to utilize the most energy efficient methods. Less energy is required to convert nitrate to ammonia to usable forms of nitrogen, if they are in sufficient concentrations, than to fix nitrogen gas. In Lake Apopka, nitrate and ammonia concentrations are high enough to be utilized efficiently by all the phytoplankton including the nitrogen fixing blue-green algae. Furthermore, at these concentrations of ammonia and nitrate, nitrogen fixation has been documented to be severely inhibited (Patriquin and Knowles, 1975; Patriquin and Keddy, 1978). In addition, the dominant blue-green algae species in Lake Apopka are non-heterocystic (Brezonik, et al, 1978; Biederman, 1978), and therefore have not been demonstrated to be nitrogen fixers (Stewart et al, 1967).

3. Terrestrial weed growth in Lake Apopka. It is understood that terrestrial weed invasion will occur when Lake Apopka is drawn down.

Several potential problems associated with this invasion of terrestrial vegetation include uprooting during refill and decomposition and nutrient release after refill. For a more complete discussion of these problems see Section 4. The impact of the terrestrial weed growth on the success of the drawdown is not known. This is one reason a pilot drawdown study on a smaller lake has been proposed. It should be noted, however, that herbicides will not be used in the Lake Apopka drawdown.

4. Increase in nutrients after drawdown. The Clean-Flo proposal stated that in Fox's et al (1977) study, the water quality did not improve but returned to control conditions after drawdown. They therefore see no reason to expect an improvement in water quality following the Lake Apopka drawdown. A more thorough investigation of Fox's study would have shown that after the initial increase in nutrient levels following refill, both nitrogen and phosphorus concentrations decreased and remained below control levels. Discussions of subsequent studies on the effects of drawdown on sediment nutrient release can be found in Section 2. It is expected that the nutrient release from the compacted sediment will be substantially less following drawdown.

5. Rooted macrophytes and the sports fishery in Lake Apopka following drawdown. The Clean Flo proposal states that their restoration method will not result in an increase in rooted aquatic vegetation. They state that the lack of macrophytes will eliminate escape cover for minnows and other forage fish and therefore improve the sport fishery. However, most fishery biologists would agree that a healthy stand of rooted aquatic vegetation is required for a self-maintaining sport fishery. Under conditions of no macrophyte establishment, populations of prey species would quickly become depleted. In addition, young sport fish would have no escape cover and would quickly be reduced in numbers through predation. The resultant fishery would consist of some large predators with few or no juveniles to replace the mature fish caught by fisherman.

6. Excessive growth of water hyacinths and Typha in Lake Apopka following drawdown. Clean Flo have extrapolated some of the results of

Fox's et al (1977) study rather generously. Water hyacinths germinated only on sandy sediments during the test study. Lake Apopka has very few areas where sandy sediments will be exposed during drawdown. Therefore, water hyacinths are not expected to be a problem. Furthermore, Typha is not considered an entirely undesirable macrophyte.

7. Presence of Aeromonas in Lake Apopka. The alligator and fish kills during the 1971 gravity drawdown of Lake Apopka were not definitely attributed to Aeromonas. Although Aeromonas is present in the Oklawaha Chain of Lakes, it has not been proven to be the cause of any kills.

8. Retention time of Lake Apopka. The retention time for Lake Apopka is approximately 6 years (Brezonik et al 1978). Evaporation was not included in this calculation because most limnologists and hydrologists include only processes which involve input or removal of consitutents from a lake in their calculations of retention time. Nutrients, trace metals and salts are not removed by evaporation. The inclusion of evaporation by Clean Flo in their calculation of the retention time for Lake Apopka resulted in the unrealistically low estimate of 0.8 years.

# Hyacinth Systems

2603 N. Indian River Drive
Cocoa, Florida 32922

January 25, 1979

Ms. Suzanne Walker
Florida Department of
Environmental Regulation
7601 Highway 301 North
Tampa, Florida 33610

Dear Suzanne:

Please accept my apology for the delay in preparing and delivering the enclosed material to you. Please review this material as objectively and as carefully as possible for the implications are significant. For further help, the following people may be able to verify or support some of this data:

| | |
|---|---|
| Dr. Larry Bagnall<br>(University of Florida - solar driers, presses) | (904)392-1864 |
| Evan L. Keesling<br>(Feed Producer) | (305)339-3700 |
| Robert C. Reach<br>(Environmental Engineer) | (305)683-3301 |
| William C. Wolverton<br>(NASA) | Bay St. Louis,<br>Mississippi |

If you need additional information, please contact me at (305)275-3011 during the day, or (305)636-5796 at night. Your efforts expended on the Lake Apopka problem are truly appreciated, and your Department is to be commended for its patience and perserverance in dealing with the many difficulties which have arisen.

Sincerely,

E. A. Stewart, III

EAS/cwt

Enclosure

copy to: Archie Carr, III
Florida Audubon Society
Maitland, Florida

## PRELIMINARY COST CONSIDERATIONS

## HYACINTH SYSTEMS WITHIN LAKE APOPKA

The following conditions are used throughout this evaluation:

- Interest rate of 7%
- Electricity costs . . . . $0.04/kWh
- Labor costs, including fringe benefits . . . . $8.00/hr.
- Land costs . . . . $2,500/acre

The operation will be designed around 15,000 acres of hyacinth growth within the lake itself. Long growing channels will be formed by using secured floats with nylon rope forming each chamber. The channels would be long and narrow with each being separated from the other by a channel of open water.

The floats will be placed every 100 feet and be connected to 1 cubic foot solid concrete block. These blocks cost approximately $10 each installed. Cost for 1-inch nylon rope is set at $0.20 per foot and styrofoam floats spaced every 8-feet costs $0.10 each. Each cannnel will be 600 feet wide. This means 2,178,000 feet of rope. Therefore, the number of floats needed is 272,250 at a cost of $27,225. The rope cost is $435,600, and the secured floats would cost $217,920.

For harvesting, 5 hp hidrostal submersible pumps capable of removing 20 wet tons per hour would be utilized. With control panels and appurtenances, these pumps cost about $5,000 each installed. Using growth rates of 100 dry pounds or 1 wet ton per day per acre, and harvesting to maintain a steady state, it can be found that using the pumps 8 hours per day a total of 94 pumps are needed. If a 5% reserve is maintained, then 100 pumps will be required with an initial cost of $500,000.

Processing equipment will include screw presses and solar driers. Each press can handle 28 wet tons per hour and costs $15,000 each. Again, using a 5% reserve, this amounts to $1,050,000. For drying, pressed hyacinths at 80% moisture can be loaded at 2122 $ft^2$/ton at a cost of $1.00/$ft^2$.

The daily tonnage at 80% moisture is 3,750, requiring $8 \times 10^6$ sq. ft. of solar drier, at a cost of $8,000,000. This also will require the purchase of 185 acres of land at a cost of $396,650. Additional costs will include boats, conveyor system and support vehicles at an estimated cost of $500,000. Assuming no inflation and the life of the pumps and presses is ten years, the present worth of the capital costs is estimated at $11,127,395.

Operation and maintenance could be done with a force of 20 men working full time for an annual cost of $332,800. Annual electrical costs would amount to approximately $204,331. Annual sales of the crop at 15% moisture and $15 per ton and considering a 20% crop loss amounts to $3,864,700. This results in an annual operating cost of negative $3,327,570, or a ten-year profit of $20,408,317. This brings the total project net worth to a profit of $9,280,922.

The question then is not only will hyacinths restore the lake, but can they also result in a net economic gain in the process? Needless to say, several questions must be addressed.

- Is the market feasible?
- Can these production rates be achieved?
- What are the possible secondary environmental effects?
- What is the extent of the management effort?

Many of these questions will be answered through much of the on-going work on these plants (Lakeland, NASA, EPCOT, Coral Springs, etc.).

This data is not intended to be a final cost estimate. Much more time needs to be spent in design finalization. However, these values should not be discarded as totally unrealistic or completely out-of-line. This represents a very plausible and attractive alternative to your problem.

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D&A
DAWKINS & ASSOCIATES, INC.
CONSULTING CIVIL AND ENVIRONMENTAL ENGINEERS

October 11, 1978

Dr. Chuck Carr
Florida Audubon Society
P. O. Drawer 7
Maitland, Florida 32751

LE COPY

Dear Chuck:

Much of the material concerning the use of water hyacinths for wastewater management is enclosed herein. Unfortunately, the proposed alternative for Lake Apopka has not been consolidated or finalized at this time. However, to give you some initial ideas of this concept, please consider the following:

1. In analyzing the characteristics of the sediments in Lake Apopka, Schneider and Little (1969, "Characteristics of Bottom Sediments and Selected Nitrogen and Phosphorus Sources In Lake Apopka, Florida", U.S. Department of Interior, Southeast Water Laboratory, Athens, Georgia) determined that there is approximately $5 \times 10^8$ lbs. N and $1 \times 10^7$ lbs. P contained in the muck deposits within the Lake (average depth of these deposits are about 3 feet).

2. The muck contains about 3% N and 0.15% P on an average and a dry weight basis.

3. The muck places a chemical oxygen demand upon the lake system of 1100 mg/gm, or a total demand of approximately $1.83 \times 10^{10}$ lbs of $O_2$. If oxidized biochemically, the actual oxygen demand might be reduced to about $7.3 \times 10^9$ lb of $O_2$ (BOD).

4. The desired nitrogen and phosphorus levels to be held by the lake sediment must be considered to be considerably lower than these levels. Phosphorus levels for example taken from oligotrophic lake sediments by the undersigned showed levels of perhaps 0.2% for a thickness of not more than a few inches. This rapidly diminished to about zero below this level. Therefore, the active transfer area within the sediment is quite limited. For Lake Apopka, the theoretically desired sediment held nutrients in this active zone is estimated at $2.5 \times 10^7$ lbs. N, $1.73 \times 10^6$ lbs. P and $9.15 \times 10^8$ lbs. BOD (based on a 0.25 ft. active transfer zone).

5. The desired nutrient removal level, therefore, is $4.75 \times 10^8$ lb. N and $8.27 \times 10^6$ lb. P. In addition, the annual allocthonous load of approximately $1.46 \times 10^6$ lb. N and 394,200 lb. P must also be removed.

6. The demand upon the water hyacinths, therefore, is to remove in a period of five years $4.82 \times 10^8$ lb. N, $1.024 \times 10^7$ lb. P and $6.39 \times 10^9$ lb. $BOD_5$.

7. A reasonable productivity rate for hyacinths grown in the lake would be 80 — 100 lbs per dry matter per acre-day. This material can be expected to be about 3% N and 0.4% P. Actual studies on nutrient removal rates indicate, however, that other factors besides plant uptake are involved. Nitrogen removal rates for example have been shown to be as high as 59 lbs. N per acre-day by Cornwell et. el (1977, "Nutrient Removal by Water Hyacinths, SWPCF, 49:1). In Texas, Dinges (1976, "Who Says Sewage Plants Have To Be Ugly", Water and Wastes Engineering, 13:4) found removal rates of 16 lbs per acre-day. Phosphorus removal rates varied between 2 — 16 lbs. per acre-day. These of course are mostly for hyacinths grown in secondary effluent. Therefore, what can be expected in the case of those grown in "natural" waters is unknown. For purposes of this exercise, suppose the Nitrogen removal involved uptake plus denitrification and amounted to 20 lb. per acre-day. Phosphorus removal would involve only plant uptake and would amount to 0.5 lb. per acre-day.

8. Using 15,000 acres of hyacinths within the lake would, therefore, require 4.4 years to remove the desired nitrogen and 3.7 years to remove the desired phosphorus. The resulting crop would be 1.42 x $10^6$ tons of hyacinths at 15% moisture worth about $15 to $20 per ton, as a dairy cattle feed ingredient (personal communication with Evan Keesling -- Dairy Feed Producer), or a gross total value of $28,000,000. The hyacinth cover would also inhibit greatly the phytoplankton productivity within the lake. If additional flushing could be utilized during this period, the effectiveness of the program would be further enhanced.

Please understand that these are very rough preliminary calculations. A brief demonstration project would allow better definition of the dynamics of hyacinth growth in the lake and the impacts of the continual treatment upon the sediment dynamics within the lake. The concept, however, is sound and, with proper investigation and planning, could be more than competitive with the present drawdown scheme.

It is hoped this data will be of some assistance to you. We will send additional information as we develop some reasonable cost data to accompany our ideas. If we may be of any additional help, please call.

Sincerely,

DAWKINS & ASSOCIATES, INC.

FILE COPY

E. A. Stewart, III
Environmental Specialist

EAS/cwt

Enclosures

TWIN TOWERS OFFICE BUILDING
2600 BLAIR STONE ROAD
TALLAHASSEE, FLORIDA 32301

BOB GRAHAM
GOVERNOR

JACOB D. VARN
SECRETARY

STATE OF FLORIDA
**DEPARTMENT OF ENVIRONMENTAL REGULATION**

March 13, 1979

Mr. E. A. Stewart III
2603 N. Indian River Drive
Cocoa, Florida 32922

Dear Al:

Thank you for sending us your proposal for hyacinth removal of nutrients in Lake Apopka. While we realize that this is a preliminary document, we have researched some of the critical aspects of this approach and offer the following comments:

I. Preliminary Cost Considerations

A. Underestimates

Although we were unable to check the estimated cost of each item in the proposal, we did check the unit price of rope since it is a common item and would be required in massive quantities for this project. Conversations with a Tallahassee rope manufacturer indicate that 1-inch twisted nylon rope retails for $1.08 per foot and wholesales for $0.66 per foot. The wholesale price of this rope is over three times that used in your proposal adding at least $1 million to the total cost. Other items, because they were not fully described in the proposal, were not checked. These cost factors may also be underestimated.

B. Additional Costs

In reviewing the proposal, we found several instances where a cost estimate for a needed process was not included. Two examples are given below:

1. Cost of setting up rope, floats and blocks to form channels. We expect that construction of this large network will require substantial labor costs.
2. Treatment of liquid waste (see Section V).

Inflation for labor, fuel, electricity and maintenance should also be included. Over the life of a 10-year project, inflation for continued expenses must be considered significant.

II. Size of System

The entire lake will be covered by structures related to the project (15,000 acres of hyacinths and 15,000 acres of clear channels, separated by rope, floats and block structures).

A. This precludes virtually any recreational or commercial use of the lake during the 10-year project.

B. Such a widespread structure cannot be protected against vandalism. Although vandalism of the open water structures would probably not endanger the success of the restoration, such damage could result in very costly repairs.

III. Placement of Land Facilities

A. Assuming that the 185-acre piece of land to be used for the processing plant is a single continuous unit rather than many small units around the lake, portions of the hyacinth growth will be up to 10 miles away from the point of processing. We foresee major transport problems involved here (see Section IV).

B. There may be considerable difficulty finding a continuous 185-acre piece of lake-front property that is not in a wetland area, in which case permitting agencies would have to be involved before plant construction could begin.

IV. Transport of Hyacinths to Processing Facility

The proposal does not make clear the logistics of pump placement. The pumps could all be placed on shore, near the processing plant, but then hyacinths would have to be pushed as much as ten miles to the pumps. On the other hand, pumps could be placed on boats and the pumped hyacinths transferred to the processing facility by barge. On a lake the size of Apopka, any energy saved with the use of low energy pumps is exceeded by that required as a result of the transport distances. Therefore, both of these methods appear to be very energy intensive.

V. Liquid Waste from Presses

Using your figures, we estimate that 200,000 gallons of nutrient-rich hyacinth juices will be produced per day. A conversation with Dr. Larry Bagnall indicated that there may be a problem in treating this "waste water." The filtration and centrifugation treatment has been found to be highly energy intensive. Sedimentation is being considered as an alternative; however, we have previously explored the idea of sedimentation basins on Lake Apopka and found the construction techniques needed to build these basins to be very costly. In addition, both of these methods remove only solids; the dissolved phosphorus is not affected.

### VI. Starting Hyacinth Growth

How will the growth of 15,000 acres of hyacinths be promoted? Currently, hyacinth densities on Lake Apopka do not even approach that figure. The relatively low densities at present may be due to a biological control program using the hyacinth weevil or due to the natural occurrence of a hyacinth fungus (cercosporarodamanii), recently isolated downstream in the Rodman Reservoir.

### VII. Project Termination

Assuming that 15,000 acres of hyacinths can be grown, how will the hyacinths be removed at the end of the project? The proposed harvesting facilities can only accommodate an amount equal to the daily growth of the 15,000-acre standing crop. Any method other than mechanical harvesting (e.g., use of herbicides, biological control) would be unacceptable, as these methods would return nutrients to the lake and contribute additional organic material to the muck layer.

### VIII. Effect on the Muck Layer

The proposed method of treatment, if successful, could remove nutrients from the water column; however, it would not appear that this system would reduce the area of lake bottom covered by muck. Reduction of muck is a major consideration in the return of rooted aquatic vegetation and game fish populations. The proposed project could contribute both nutrients and solids to the muck layer through sloughing off of senescent vegetation (Sheffield[1] as cited in Cornwell et al.[2])

### IX. Market Feasibility

Mr. Evan Keisling seems to be confident that a market would exist for the project's product. However, he also indicates that little or no research has been done to determine the feed mixing concentrations for optimal milk production and growth of cattle.

The items discussed above are serious concerns and would have to be addressed before the department could consider this approach as a viable alternative for the restoration of Lake Apopka.

If you have any questions or comments concerning this letter, please feel free to contact me in writing or by phone at 904/488-9560. Again, thank you for your interest in this project.

Sincerely,

Vern B Myers

for Suzanne P. Walker
Field Project Director
Water Resources Restoration
and Preservation

SPW:nm

cc: Archie Carr III

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[1] Sheffield, C.W., 1966. Removal of nitrogen and phosphorus after secondary sewage treatment. MS dissertation. U. of Cincinnati.

[2] Cornwell, D.A., J. Zoltek, Jr., C.D. Patrinely, T. Furman and J.I. Kim, 1/1977. Nutrient removal by water hyacinths. Journal WPCF. pp. 57-65.

2603 N. Indian River Drive
Cocoa, Florida 32922

March 16, 1979

Mr. Vern B. Myers
Florida Department of
Environmental Regulation
Water Resources Restoration
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32301

Dear Mr. Myers,

I was most disappointed with your recent letter commenting on the possibility of using water hyacinths for lake restoration. Most of your comments could be classified as quibbling remarks which apparently stemmed from a bias for one particular approach to restoration -- namely, drawdown.

I don't believe I need to remind you of the dangers of such thought contamination, particularly in the field of environmental planning.

Before addressing your review comments, I would like to reiterate the statement from my letter of January 25, 1979 to Suzanne Walker:

> "This data is not intended to be a final cost estimate. Much more time needs to be spent in design finalization."

The point is, I have given my time to the Department because I am concerned about the future of lake restoration in Florida. I am somewhat insulted that you discarded my "free" input so readily. It appears to me that you don't really want to investigate additional alternatives objectively, therefore you may consider this as my last "free of charge" contribution to your effort.

Proceeding with your comments:

## I. Preliminary Cost Considerations

The point of rope cost is hardly worth bickering over. However, if you must use this rope at $0.66/foot, that would be alright, as we have a potential $20 million dollar, 10 year cost flexibility to work with between this alternative and the proposed drawdown. Remember, this was a very rough cost analysis as I noted several times. Perhaps 1/2" rope would suffice? Let us assume my estimates were 300% low, this brings the rope and secured float costs to $1,961,000.

Undoubtedly, there will be substantial labor costs for setting up this network of ropes and floats. Note the block costs of $10 included installation. However, to compensate for the additional labor, it might be legitimate to add $500,000 to the total cost.

Inflation is a factor that is always excluded in present worth economic analysis. The reasoning, of course, is that inflation is relative. Therefore, the analysis must be based upon some set dollar value. For example, your engineers used September 1978 for the Apopka drawdown analysis. Nowhere did they consider inflation which, of course, is quite legitimate.

## II. Size of System

Why does 15,000 acres (43%) exclude commercial or recreational use? The growing channels can be situated in such a manner that boat movement would be possible through the open areas. In fact, fishing might be improved as well. The hyacinth cover would encourage development of a diverse food web. Nature studies, canoeing, and the educational and recreational benefits of the lake also could be realized.

Vandalism will be a problem with any program or structure. However, there is very little about this plan that is appetizing to the vandal mentality. Consideration of this problem would be included in the overall managmeent program. Certainly it would not be so immense a problem as to justify elimination of this alternative from further consideration.

## III. Placement of Land Facilities

Please don't assume that the 185 acres would be in one place. I see rather distinct treatment and processing units placed around the lake with several central harvesting and processing areas. It would take some imagination to design this system, but certainly it would not be an impossible task. One idea would be to have the pumps located on shore with the channels emanating outwards in a semicircular fashion, such as shown in the rough sketch included herein. In short, an efficient design would resolve the transport problems.

With this scheme, 185 acres of continuous lakefront would not be needed, and wet land involvement might well be avoided. Again, this comment appears to be quibbling. Permitting is a consideration with any alternative.

## IV. Transport of Hyacinths to Processing Facility

Pump placement again is a design consideration. Looking, however, at the rough sketch, it can be seen that the pumps could be placed in a battery almost contiguous to the processing area. Hyacinth growth would be encouraged to be outwards towards the periphery. The plants would move gradually towards the harvest area. Pushing of the hyacinths is rather easy, and often may not be necessary, as the void left by recent harvesting will often be filled by natural forces. Again, proper design and management will solve many of these problems.

## V. Liquid Wastes from Processes

I would not refer to a nutrient rich, pathogen-free water, as a wastewater. The ultimate fate of this water might well enhance the economic worth of the project, instead of detract from it. While it is not known exactly what the composition of this exudate will be, it is estimated that it will contain no more than 25 percent of the total nutrient load contained within the harvest. Theoretically, this water could be returned to the lake, meaning the period for restoration would be adjusted by a factor of 1.25. This might also return trace minerals and growth factors to the system, which are critical to hyacinth growth. For example, in Lakeland, we are finding iron deficiency to be a problem with hyacinths. Return of this water to the lake might well improve the system's effectiveness. This, of course, may not be the best method of disposal. Use on crops as a fertilizer supplement might well be more practical. The nursery business of the area could possibly utilize this water. Certainly filtration and centrifugation would not be the most practical approach. Use of wetland or a series of treatment lagoons with vascular plants might also be utilized. The problem is not an insurmountable one, nor does it appear to be one that will elevate the costs significantly.

## VI. Starting Hyacinth Growth

Recently I heard that the GFWFC sprayed 6,000 acres of hyacinths on Lake Apopka. This is not that far from 15,000 acres, when it is realized that these plants may double their area in less than 10 days given the right set of circumstances. The weevil does not seem to deter productivity that much from our experience. Your concern for the hyacinth fungus is quite legitimate however. It is also a fear that I share. Great precautions would have to be taken to prevent contamination of the crop. An extensive prevention program would have to be devised. Hopefully the fungus will not be used indiscriminately throughout the state, as hyacinths are likely to become a valuable crop for Florida.

## VII. Project Termination

Remembering that harvesting is done for eight hours a day, it would be necessary to begin harvesting at ten hours a day during the last year of the project. This would allow a steady reduction of the standing crop over a year's period. Using a wet density of 90-100 tons/acre, the removal would be complete with 350-420 days. Some additional cost would be associated with this, but much of it would be countered by an increased crop income.

## VIII. Effect on the Muck Layer

The sloughing referred to by Sheffield and Cornwell, et al is when harvesting is not done on a regular basis. It must be remembered that the hyacinth will dominate productivity. Phyto plankton should not be a real factor because of shading and nutrient competition. Therefore, there will be a net respiration throughout the system. The bottom muck will serve as a carbon source for this respiration throughout the program. The net effect should be a reduction of organic solids and a consolidation of the sediments. I would suggest you do a nutrient balance of the proposed system in order to predict carbon and nutrient losses from the sediments.

IX. Market Feasibility

We should have information on this item very shortly. Certainly it is critical to the success of the project.

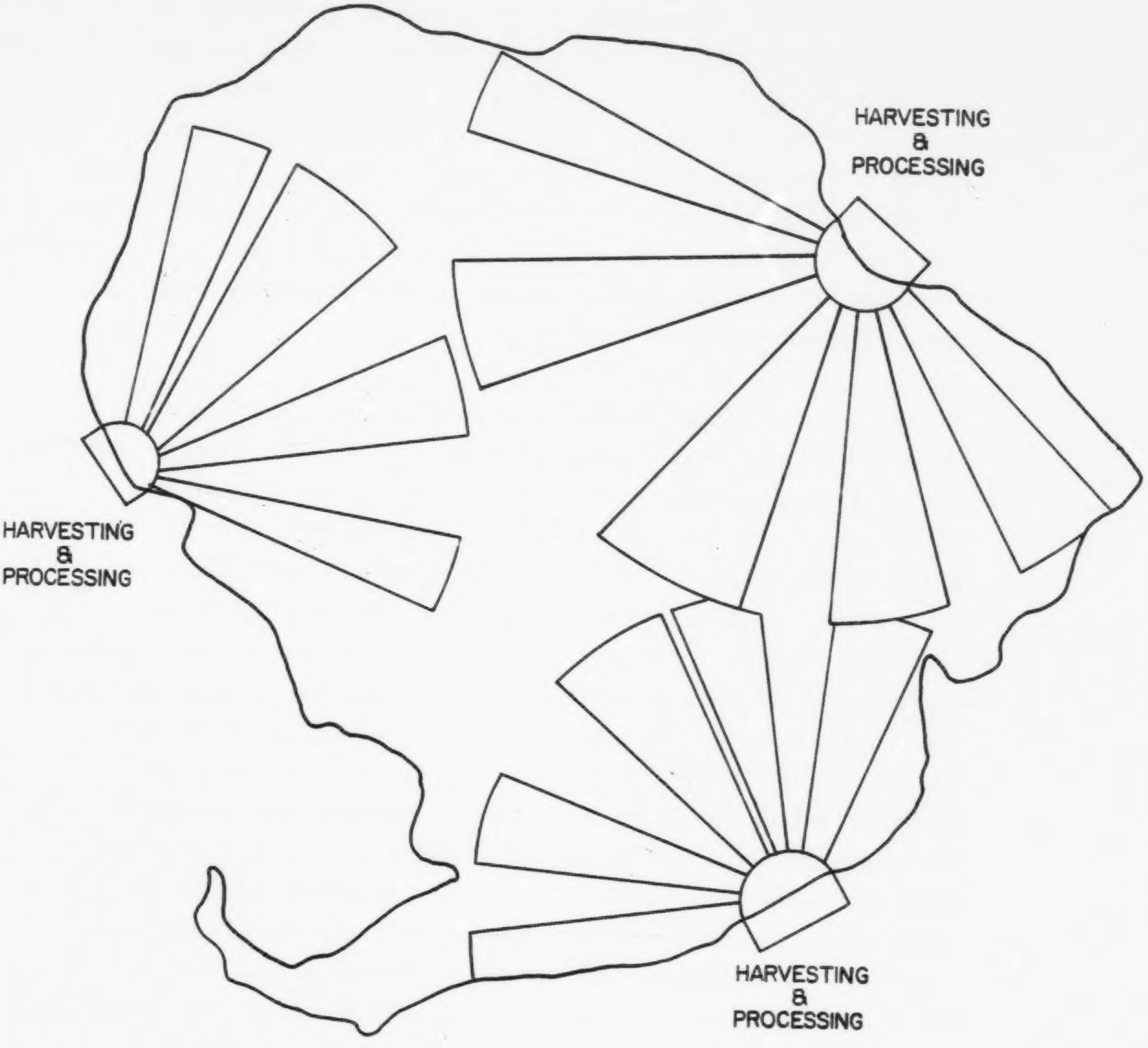
I do not believe this discussion will have any impact upon the restoration scheme for Lake Apopka, as it is evident that you intend to proceed with the drawdown which I might add is extremely vulnerable to legitimate criticism -- criticism which you apparently have ignored. I am not trying to force the hyacinth plan on you, I merely thought it made more sense economically and environmentally. If you truly do not believe it is a viable alternative, then proceed with your present path. However, I believe it would be to your benefit to reassess your position one more time.

Before closing, I would like to request that all of our communications be included in the final EIS, and that the hyacinth system be evaluated within the text as one of the alternatives considered.

Sincerely,

E. A. Stewart, III

EAS/jlw


HARVESTING
&
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PROCESSING

LOCATIONS OF HARVESTING AREAS
ARE HYPOTHETICAL

Further Response

There are distinct advantages to the use of natural biological systems for treating environmental problems. Certain biological systems have evolved which can effectively mitigate some of the problems of eutrophication. Aquatic macrophytes can compete effectively in certain instances with phytoplankton and can reduce the adverse effects of nutrient enrichment. However, at the current time the technology of the use of water hyacinths is not sufficiently developed to be either scientifically or economically feasible in restoring Lake Apopka.

The most serious concerns with this proposal are the effects of water hyacinth growth on muck consolidation, the effects of harvesting and processing the hyacinths on water quality, and the marketability of the by-products of harvesting hyacinths. Lake Apopka has a tremendous amount of muck (200,000,000 $m^3$) associated with its bottom. The large amount of nutrients is contained in this flocculent material. The ability of water hyacinths to utilize the nutrients in the muck and to reduce the muck layer is presently a matter of conjecture, and the ten year period estimated for this removal is purely speculative. Harvesting and processing the hyacinths before marketing will produce approximately 750,000 liters per day of liquid wastes. Returning this waste to the lake would seriously prolong this already very long-term restoration plan. Also, the wastes would have to meet state standards before they could be discharged into the lake. Marketing the liquid wastes as a possible fertilizer has not been proven viable. Furthermore, a large market would be needed for the by-products of the harvested hyacinths. Currently, economically acceptable methods of using the hyacinths' by-products as cattle fodder, citrus mulch, or to produce methane are not available. Although natural biological restoration processes have potential, the water hyacinth proposal does not currently represent a viable alternative which will restore Lake Apopka.

# Sectioned Drawdown

BROMWELL ENGINEERING

RECEIVED
APR 9 1979
D. E. R.
Water Resources Management

April 5, 1979

Lake Apopka Restoration Project

Ms. Suzanne Walker
State of Florida
Department of Environmental Regulation
Water Resources Restoration and Preservation Office
Twin Towers Office Building
2600 Blair Stone Rd.
Tallahassee, Florida 32301

Mr. John E. Hagan
Chief, EIS Branch
EPA Region IV
345 Courtland St., NE
Atlanta, Georgia 30308

We have reviewed the Environmental Impact Statement on the Lake Apopka Restoration Project. Enclosed are our comments on this interesting endeavor. We feel that by quartering the lake with dikes and performing successive draw-downs, the project will be more successful and less expensive. The work can be done in phases meaning that satisfactory results can be insured prior to committing additional funds.

We would like to help develop the concepts of this project so that it can be funded and brought to a successful conclusion.

Sincerely,

BROMWELL ENGINEERING

Neil R. Greenwood

Neil R. Greenwood, P.E.

NRG:se

Enclosure

202 Lake Miriam Drive • P.O. Box 5467 • Lakeland, Florida 33803 • 813/646-8593

# LAKE APOPKA RESTORATION PROJECT

A review of the Lake Apopka Restoration Project was made to examine the improvement procedure and to form an opinion on the cost-effectiveness of the project.

The lake and its environmental factors have been closely studied and the data provided is very thorough. The analysis of the problem and the effectiveness of the potential solutions were also well thought out. The proposed action, however, is lacking in several areas and its advisability is questionable.

The proposed project has the high cost of $14,000,000. This is a lot of money to allocate for a project which has an uncertain probability of success. The water level over the entire lake is to be down 9 feet which will expose only 30% of the lake bottom. An equal area will remain completely unaffected. The muck on the remaining 40% may be partially upgraded depending on the mobility and performance of the muck. The surface may consolidate as proposed but it is more likely that the muck will just thicken from its present consistency of 4-8% to 8-16%. The same amount of solids will fill a smaller volume. As long as the water remains at a fairly high level in the muck it is doubtful that adequate consolidation will take place. The problem is similar to that encountered in the phosphate industry with reclamation of slime ponds. It is necessary to decant all the water from the surface of the solids in order to form a crust and obtain a sufficiently high consolidation.

Besides the questionable effectiveness of the proposed draw-down procedure the project will have a detrimental effect on other lakes and communities. Temporary dikes, boat lifts, silt carry-over and large pipelines will cause inconvenience to others. The entire lake will be of no use during the operation with the accompanying esthetic annoyances. Timing of the work must be right to cope with the frost season. Delays at the wrong time will prolong the project an entire year.

Bromwell Engineering
April 5, 1979

An alternate proposal is suggested that takes advantage of the data obtained and the principles advocated in the EIS report. It is proposed that dikes be constructed either by dredge or by dragline to section off part of the lake at a time. The isolated section would be pumped out as low as possible to gain maximum exposure of the muck on the bottom. Four different draw-down areas are envisioned but the size and shape are not important. The smaller area of muck would be consolidated with minimal freeze danger to the surrounding area. The necessary development work needed to obtain the best procedure to remove the water without the muck could be accomplished without a critical time schedule problem. With the water level down as low as necessary and the muck dried out, it might be possible to harvest the vegetation from the bottom if it is warranted.

When the initial segment is ready for refilling and the next dike is in place the completed area can be partially filled by gravity from the second treatment area. Pumps will be used to complete the next draw-down and the procedure is repeated as many times as is necessary.

It is estimated that the cost for the entire project with four draw-downs might be about $3,000,000. The first area would cost much less and the entire funds would not be spent until the initial phase has proven successful. The probability of success is much higher, the cost is lower and the disruption of the surrounding area is avoided.

Bromwell Engineering
April 5, 1979

BROMWELL ENGINEERING

April 20, 1979

APR 25 1979
D. E. R.
Water Resources Management

Mr. Erwin Y. Liang, P. E.
Office of Water Resources,
Restoration and Preservation
State of Florida
Dept. of Environmental Regulation
2600 Blair Stone Road
Twin Towers Office Building
Tallahassee, Florida 32301

Dear Erwin:

Enclosed is a letter to Mr. Hagan summarizing my comments following the public hearing on the draft EIS for the Lake Apopka Restoration Project.

Since my associates and I are involved with dredging, earth dam designs, soils, and fine particle consolidation, the idea of constructing earthen dikes by dredging was an obvious choice to us. A very rough estimate on dike volume is 2.3 million cubic yards at a cost of $2,000,000. Seepage is estimated at 60 gpm/1000 feet. Some of the important points that need to be considered in the design and layout of the dikes include 1) lake depth, 2) muck depth, 3) lake bottom soil characteristics 4) irrigation needs of both groves and muck farms, and 5) frost protection for the groves. It is possible that some of the lake would not be treated at all as either being unnecessary or unproductive.

My goal was to save $10,000,000 on this project without sacrificing any quality. This goal has been made much easier now that the cost has risen to $19,800,000. A savings of $15,000,000 is not unreasonable.

I would like to correct a statement I made in our discussion Tuesday night. The dike volume was based on a 4:1 slope and not 6:1. However, this number would need refining during engineering design and I obviously have not carried it beyond the preliminary conceptual stage.

202 Lake Miriam Drive • P.O. Box 5467 • Lakeland, Florida 33803 • 813/646-8593

Please let me know if you would like additional information regarding this proposed approach. I believe that there are other advantages that will be revealed with further study.

Sincerely,

BROMWELL ENGINEERING

Neil R. Greenwood

Neil R. Greenwood, P. E.

NRG:se

BROMWELL ENGINEERING

April 19, 1979

Mr. John Hagan
Chief, EIS Branch
EPA, Region IV
345 Courtland St. NE
Atlanta, Georgia 30308

Dear Mr. Hagan:

The public hearing on the draft EIS for Lake Apopka Restoration brought out some interesting comments which have a bearing on my suggested alternative approach to the project. The opposition voiced at the hearing came from:

1. The citrus owners who felt that they were not being sufficiently protected.
2. Land owners on downstream lakes who don't want any water quality degradation.
3. Taxpayers who feel that the cost is too high.

These people question whether the predicted results make the project worthwhile.

By constructing dikes to permit a drawdown on one section of the lake at a time, not only are all of the above problems dealt with, but improved restoration should be attained. The dikes would permit normal levels to be maintained in major portions of the lake during sectional drawdown. The most critical lake areas for citrus could be scheduled during warmer months.

There would not be the need to pump the entire lake down rapidly. This would relieve the flood of water into downstream lakes and eliminate the dams, pipeline and pumps in the other lakes. Only during drawdown of the first section would the discharge flow increase and the rate and timing of this could be made to accommodate canal capacity.

202 Lake Miriam Drive • P.O. Box 5467 • Lakeland, Florida 33803 • 813/646-8593

The earthen dikes could be constructed by dredging suitable material from the lake bottom below the muck. Although a detailed engineering design would be required, initial estimates indicate the dikes might cost $2,000,000. This cost could increase by a factor of 2 or 3 and still result in savings of $12,000,000 to $15,000,000 over the recommended action. The other costs such as pumping, engineering, and maintenance are estimated to be in the $1-2 million range for the sectional dike concept, leading to a total cost in the range of $3-4 million.

The other big advantage of this alternative approach is the likelihood of doing a better job of muck consolidation. It is felt that there is a good chance of lowering the water level in the section being treated below elevation 58 feet MSL. This would result in producing a strong bottom crust on more than 30% of the lake bottom. It would reduce the 30% area that would be unimproved with the procedure recommendations in the EIS. It may even be possible to use the dredge to transfer heavy muck from the deep holes to the muck farms to revitalize the soil.

Vegetation is expected to grow on the exposed lake bottom. Although this may create debris and disturbance of the consolidated muck upon refilling, harvesting is not possible with the soft bottom left with the original scheme. This alternative proposal should provide enough firm lake bottom to allow coping with vegetation prior to refilling.

The initial limited drawdown that would result from this alternative would provide many of the answers on procedures and schedules to use to optimize restoration. Time and cost constraints will not permit such additional information to be developed with the EIS project format.

As was mentioned in the hearing, this is not the time and place to criticize, but to offer constructive suggestions. The environmental studies and restoration analyses in the EIS are very good. I feel that if this background information can be used to engineer a better job for less money and less potential impacts on the area, the restoration project will be worth undertaking.

Sincerely,

Neil R. Greenwood, P. E.

NRG:se

c.c. State of Florida
DER
Tallahassee, Florida

Mr. Neil R. Greenwood, P.E.
Bromwell Engineering
202 Lake Mariam Drive
Lakeland, Florida 33803

Dear Mr. Greenwood:

Thank you for your letter expressing concern about Lake Apopka and the proposed lake restoration scheme. After very careful review of your proposal by our technical staff, however, it appears that your lake restoration design has many of the same problems as the current plan designed by Ross, Saarinen, Bolton & Wilder (RSB&W) and presented in the Draft Environmental Impact Statement (DEIS). In formulating our comments on your proposal, we have attempted to be as thorough as we could and raise every question and issue which might occur if your proposal were substituted as the recommended alternative in the DEIS. Therefore, please accept our criticisms in the constructive spirit in which they are offered.

Based on our understanding of your proposal, the opinions of several dredging contractors, and the cost estimating work done by RSB&W, we have reached the conclusion that your proposal will not only cost substantially more than the current RSB&W plan, but will also have no more significant advantages. Furthermore, the following is a list of serious concerns which will undoubtedly affect the success of your proposed drawdown. We realize your design is only in the preliminary stages and we certainly do not wish to discourage you, but these problems must be addressed adequately in any drawdown/restoration project. In the following discussion, your proposal is, as you mentioned, assumed to use an earthen dike to divide the lake evenly into four sections.

1. Downstream turbidity and water quality degradation:
   There is no reasonably cost effective man-made sedimentation basin and chemical treatment system which can ensure that the effluent from Lake Apopka will meet design constraints (page 114, Draft EIS). The current RSB&W plan uses an in-lake sedimentation basin for removing heavy particles and Lake Beauclair for removing fine particles. This arrangement can ensure that effluent from Lake Beauclair will meet design constraints and water quality in downstream lakes will not be degraded. Lake Beauclair will be restored by drawdown to mitigate any damage caused by the Lake Apopka drawdown. Your proposal also must require some form of sediment control for removing suspended particles in order to meet the design constraints. Consequently, your proposal may also require the restoration by drawdown of Lake Beauclair. In other words, as far as downstream water quality degradation due to turbidity is concerned, your proposal (as explained) offers no more advantage than the current RSB&W plan.

   Likewise, similar problems exist in both your restoration proposal and the RSB&W plan in terms of dissolved nutrients and their effects on downstream lakes. During the RSB&W plan, the immediate effects of the nutrient-laden Lake Apopka water on downstream lakes will occur for about a year during the drawdown and holddown phase. With your proposal, smaller quantities of Apopka water will be released at any one time, but downstream lakes will still be affected. Furthermore, the extensive dredging activities suggested in your proposal will release substantial quantities of interstitial nutrients which may affect the downstream lakes. Adequate measures must be designed to minimize such impacts.

2. Citrus owners' concern:
   The current RSB&W plan, lowering the water level to 64 feet MSL (only a two percent reduction in water surface area), has already caused great concern to citrus owners. They worry that the reduction of heat storage capacity may jeopardize their thermal protection received from Lake Apopka. In your proposal, the rate of the pumped drawdown of each section is limited by the capacity of the Doral Canal, and the lake has to be refilled prior to each winter season. In otherwords, it will take one year to restore each section of the lake.

   Your proposal, reducing the water surface area and volume by at least 25 percent (if refill water for the restored section is, as you said, from the rest of the lake) for four years, may cause greater concern to citrus owners than the current plan. Furthermore, if refill water is needed from downstream, then facilities would have to be designed and constructed to store such water. The Dead River Dam and Boat Lift may consequently be needed to protect Lake Harris. Facilities (cofferdam & pumps) would have to be installed for each refill period, then removed for the following year's drawdown, then installed, then removed and so on. This would increase the cost. We presume you have considered this and found an acceptable alternative. Possibly you have designed a plan that ensures that no refill water will be needed from downstream lakes. We are uncertain of your plans concerning this aspect of the project.

3. Probability of success:
   Your proposal indicates that in case the first section of the lake does not show that drawdown is a viable restoration approach to Lake Apopka, then the remainder of the project can be eliminated. However, major construction will be necessary in order to draw down the first section of the lake. A sedimentation basin, a deep-hole channel to convey the water from deep holes to the A-B canal, approximately a seven-mile long earthen dike, drawdown and refill pumping facilities, and facilities for restoring Lake Beauclair will be necessary. Furthermore, silt removal and dike protection of the A-B Canal may be necessary, and facilities to mitigate effects on citrus irrigation and the Farmers Dike may be required.

   Although the cost of draining the subsequent sections will be less, initial construction would be a major investment and would probably cost more than half of the total project cost.

If a pilot project is required to convince all concerned parties of the viability of the drawdown restoration, then a few acres instead of 7800 acres of the lake can be isolated for the experiment. This would be much more cost-effective because it does not require all the expensive construction mentioned previously.

4. Muck Consolidation:
There appears to be some misunderstanding on certain critical aspects of muck consolidation. The only way to consolidate the muck is by dehydration or dewatering. The consolidation process consists of two aspects: 1) the length of time the muck gets "baked" by the sun; and 2) self-weight compaction. The current RSB&W plan uses 58 feet MSL as the lowest lake stage during drawdown. Fifty-eight feet MSL was chosen based on "Hydrologic Considerations in Draining Lake Apopka - A Preliminary Analysis, 1970", by USGS. The enclosed figure was extracted from this report and shows clearly that approximately 95 percent of the bottom is exposed at elevation 58 feet MSL. At this elevation, all that is left in the lake is essentially muck. It would be technically infeasible to drain the lake any lower than 58 feet. However, if this were possible, the self-weight compaction would be increased while solar dehydration remains approximately consistent. Therefore, the percentage of exposed lake bottom would be essentially the same in your proposal as it is in the RSB&W plan. The lake still has to be refilled prior to the winter season, thereby imposing the same constraints on both restoration schemes. Logically, then there is no substantial proof that your restoration scheme will result in a "stronger bottom crust" than the RSB&W plan. You also suggested that it might be possible to transfer muck from the deep holes to the muck farms to revitalize the soil. However, we have learned that the muck farmers will not accept the dredged muck because it would ruin the existing irrigation system.

5. Terrestrial vegetation invasion and removal:
The Draft EIS did not advocate the removal of terrestrial vegetation because of its cost and the potential damage to the consolidated muck. Harvesting the terrestrial vegetation using conventional floating cutters is extremely expensive - more than 10 million dollars. Mechanical removal of terrestrial vegetation can damage the crust of consolidated muck, but deserves further consideration depending on the strength of the restored bottom.

6. Dike protection and muck farm irrigation:
Your proposal will affect the Farmers Dike and muck farm irrigation just as much as the current RSB&W plan, unless a new dike is built and pumps are installed to impound water along the north shore. However, the cost of building a new dike would be more than the cost of maintaining the existing dike. Provisions should be included in your plan to ensure the integrity of this unstable dike, particularly following refill of the lake.

7. Citrus irrigation:
Your proposal will affect the irrigation of citrus orchards adjacent to the quarter of the lake that is drawn down. Pumps and pipelines will be needed to irrigate these groves, and high rise travelers may be necessary to irrigate those groves which currently do not irrigate. Further studies would be necessary to understand the effect of the drawdown on the water table in those groves.

8. Cost Comparison:
Based on the RSB&W cost estimate in their preliminary "Final Engineering Report - Lake Apopka Restoration Project", this office has prepared a cost comparison between the RSB&W plan and your proposal:

Construction Cost

| Item | RSB&W Plan | Greenwood Proposal |
|---|---|---|
| Earthen dike (14 miles) | $ -0- | $16,100,000 (a) |
| Lake Apopka deep-hole channel & in-lake sedimentation basin | 3,671,100 | 1,900,000 (b) |
| Lake Apopka pumping station | 2,253,900 | 1,300,000 (c) |
| Lake Apopka water control structure | 35,600 | 50,000 (d) |
| Lake Dora pumping station | 1,098,000 | -0- |
| Lake Dora energy dissipator | 22,000 | -0- |
| Dora Canal by-pass pipeline | 2,232,600 | -0- |
| Lake Eustis energy dissipator | 275,100 | -0- |
| Lake Eustis pumping station | 75,500 | -0- |
| Dead River dam & boat lift | 601,200 | -0- (e) |
| Lake Beauclair pumping station | 513,300 | 530,000 (f) |
| A-B Canal lock & dam pumping station | 255,500 | -0- |
| Lake Beauclair/Lake Dora cofferdam | 159,500 | 159,500 (g) |
| Lake Beauclair/Lake Carlton cofferdam | 22,900 | 22,900 (h) |
| Citrus irrigation | 1,238,500 | 1,238,500 (i) |
| Silt removal & canal protection | 401,000 | -0- (j) |
| Dike & shoreline protection | 2,975,400 | 2,975,400 (k) |
| Muck farm irrigation | 1,024,800 | 1,024,800 (l) |
| Removal of facilities & clean-up to pre-construction conditions | 461,700 | 200,000 (m) |
| General requirement (mobilization, construction office, etc) | 200,000 | 200,000 (n) |
| Lake Beauclair deep-hole channel | 84,700 | 84,700 (o) |
| Sub-total | $17,602,300 | $25,785,800 |

From this cost comparison, it appears that your proposal will cost more than the RSB&W plan.

(a) The recommended minimum average cross section of the earthen dike:
50' wide top. 5' free board, 10:1 bank slope, 16' high (average lake depth is 6' of water and 5' of muck).

The soil underlying Lake Apopka is predominantly sand. Therefore, the most cost effective material to use to build the earthen dike would probably be sand. An earthen dike constructed of sand would have to meet the aforementioned specifications. The estimated length of earthen dikes is 14 miles ($9.2 \times 10^6$ c.y.). Therefore, the estimated cost * of constructing and later removing the earthen dike is \$1.75/c.y. x ($9.2 \times 10^6$ c.y.) = \$16,100,000.

*Estimated unit price is based on the cost estimates of three dredging contractors (Layne Dredging Co., Hallandale, FL., C.F. Bean Corp., Bellechase, LA; Marco Enterprise, Inc., Tampa, FL.)

(b) Both the RSB&W plan and your proposal require approximately the same amount of dredging for the deep-hole channel. Your proposal will require a smaller but much longer deep-hole channel than RSB&W plan. Your proposal will also require an in-lake sedimentation basin about ½ the size of RSB&W's proposed basin.

(c) Your proposal will require about 1/3 of the pumping capacity (including the stand-by pumps) required in the RSB&W plan. The pump station in your proposal will require pumps, cofferdam, sump, weir, wildlife screen, sheet piling, operator's trailer, fuel tank, fence, generator, power unit, access road, soil test, dredging, etc.

(d) The RSB&W Lake Apopka water control structure is needed only during drawdown and would be removed during refill. Due to the nature of your proposal, the Lake Apopka water control structure would have to be installed and removed four times.

(e) Detailed hydraulic and hydrological calculations are necessary to determine if a dam and boat lift structure is required to prevent water from backflowing into Lake Harris. In the cost estimate for your proposal, the dam & boat lift is assumed to be unnecessary.

(f) The Lake Beauclair pumping station is required for refill purposes. For the same reason mentioned previously, this pumping station would be installed and removed four times.

(g) The Lake Beauclair/Lake Dora cofferdam is for a Lake Beauclair drawdown, which would also be required in your proposal.

(h) The Lake Beauclair/Lake Carlton cofferdam is for a Lake Beauclair drawdown, which would also be required in your proposal.

## Operation Cost

| Item | RSB&W Plan | Greenwood Proposal |
|---|---|---|
| Labor | $ 692,200 | $ 1,320,000 (p) |
| Diesel fuel, electric power, filters, belts, etc. | 1,237,400 | 900,000 (q) |
| Irrigation operation | 52,200 | 52,200 |
| Misc. supplies and materials | 44,100 | 44,100 |
| Sub-total | $ 2,025,900 | $ 2,316,300 |

## Insurance

| Item | RSB&W Plan | Greenwood Proposal |
|---|---|---|
| Allowance for liability insurance premium for construction & operational phase, the increase of construction cost due to maintaining of in-lake earthen dike, and other required insurance | $ 1,000,000 | $ 1,000,000 |
| Sub-total | $ 1,000,000 | $ 1,000,000 |

## Credit for Salvage

| Item | RSB&W Plan | Greenwood Proposal |
|---|---|---|
| Axial flow pumps & drive units | $ 1,316,400 | $ 175,000 (r) |
| 84-inch dia. pipe | 468,600 | -0- |
| Boat lift facilities | 106,700 | -0- |
| Irrigation equipment | 377,200 | 377,200 |
| Misc. equipment | 22,400 | 22,400 |
| Sub-total | $ 2,291,300 | $ 574,600 |

## SUMMARY OF TOTAL PROJECT COST

| Item | RSB&W Plan | Greenwood Proposal |
|---|---|---|
| Construction | $17,517,600 | $25,785,800 |
| Operational | 2,025,900 | 2,316,300 |
| Insurance | 1,000,000 | 1,000,000 |
| Real Estate | 50,000 | 10,000 (s) |
| Engineering Services | 396,000 | 396,000 |
| Misc. technical services | 75,000 | 75,000 |
| Total Project Cost (March 1979 dollars) | $21,064,500 | $29,583,100 |
| Less Credit for Salvaged equipment & materials | ($ 2,291,300) | ($ 574,600) |
| NET TOTAL PROJECT COST | $19,826,400 | $29,008,500 |

(i) Irrigation facilities for your proposal will cost essentially the same as the RSB&W plan.

(j) The silt removal & canal protection of the A-B Canal may be avoided due to the smaller flow resulting from your proposal.

(k) The estimated cost of dike & shoreline protection prepared by RSB&W is an educated guess. Your proposal will affect the Farmers' Dike and shoreline just as much as the RSB&W plan. Therefore, it is fair for the sake of comparison to use the RSB&W estimation for your proposal, too.

(l) For similar reasons, the estimated cost of muck farm irrigation of your proposal is the same as that of the RSB&W plan.

(m) Since your proposal will not require Dora Canal by-pass facilities and Dead River dam & boat lift structures, the estimated cost of removing facilities and clean-up is much less than the RSB&W plan. (The cost of removing earthen dikes is not included in this item.)

(n) General requirement (mobilization, construction office, etc.): The mobilization of dredging equipment alone is $100,000. Your estimate of $200,000 is rather low for the cost.

(o) Your proposal also would require the restoration of Lake Beauclair; therefore, your proposal needs the Lake Beauclair deep-hole channel to convey water from deep holes in the lake to the pumping station.

(p) The required operation and maintenance personnel: RSB&W's plan requires 1200 man-weeks to draw down, hold down and refill Lake Apopka, restore Lake Beauclair, and provide for irrigation and dike protection. Your proposal will require 2287 man-weeks to drawdown, holddown and refill Lake Apopka four times, restore Lake Beauclair and provide for irrigation and dike protection.

(q) Your proposal does not require pumping operations at the Dora Canal; therefore, your proposal can save the cost of electric power.

(r) Your proposal requires fewer pumps but for a longer period of operation. The salvage value of pumps is 20 percent of purchase value, compared with the 50 percent used in RSB&W's plan. The cost of purchasing pumps in your proposal is estimated to be 1/3 of that in RSB&W's plan.

(s) The estimated cost of $10,000 includes the legal, surveying & other costs required to acquire the property needed for this project.

Your proposed restoration scheme was reviewed with great interest by the WRR&P staff. The restoration of Lake Apopka is a very complex project and there are thousands of ways to design it. Saving costs in one area may well be at the expense of other areas. If we have misunderstood your proposal in any manner, please contact us. Your suggestions and ideas are genuinely appreciated.

Sincerely,

Erwin Liang, P.E.
Water Resources Restoration
and Preservation Section

EL:ba
Enclosures
cc: Mr. John Hagan, Chief
EIS Branch
E.P.A., Region IV
345 Courtland St., NE
Atlanta, Georgia 30308

BROMWELL ENGINEERING

May 30, 1979

Lake Apopka Restoration Project

Mr. Ervin Liang, P. E.
Water Resources Restoration
and Preservation Section
Florida Department of Environmental
Regulation
Twins Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32301

Dear Mr. Liang:

I appreciate your reply concerning my suggestions on Lake Apopka. I am sending you another letter because there has not been a meeting of the minds on some of the major issues. If the project had to be performed either as in the RSB&W plan or as you interpret my plan, I would recommend doing neither and waiting for a better solution. The points that I would like to make are numbered to correspond with your letter of May 10.

1. I had the impression that the carry-over of silt from Lake Apopka to Lake Beauclair is not normally a problem but would be under the RSB&W plan because of the very large volume of water and the low water level to be reached in Lake Apopka. By drawing down one-fourth of the lake at a time, I intended to keep the flow rate out of Lake Apopka within the normal range. Also, the water volume in the three-fourths of the lake not being lowered would be a satisfactory settling basin for the water being pumped. It is certainly bigger than the one to be constructed with the one drawdown scheme.

In this way, the cost of the sedimentation basin could be avoided. The increased flow to Lake Beauclair would be kept within adequate bounds. In fact, only during the first drawdown would the rate be a factor since in subsequent drawdowns, the new area could be emptied into the one being filled.

It is possible that the dredging operation would have a detrimental effect on water quality. I expect that this would be minimal, utilizing normal turbidity control measures. It may be that other construction methods such as a dragline could also be employed advantageously.

2. My proposal would involve about 25% drawdown at one time. The lake area directly in front of the citrus groves could be kept at a high level during the frost season.

202 Lake Miriam Drive • P.O. Box 5467 • Lakeland, Florida 33803 • 813/646-8593

One of the big problems with the original scheme was fitting everything into the time between frost seasons. I anticipate that with the quartered system only one section would have to fit in that time sequence.

I really did not anticipate a four year project and expected it to take less than two years. However, a major advantage of the proposal is that it allows flexible time scheduling in order to optimize muck consolidation.

I would not obtain water from downstream to fill up the last section but would reduce the water leaving Apopka until it is full again.

3. The first section would indeed be the most expensive although the sedimentation basin, deep-hole channel, Lake Beauclair and A-B canal rehabilitation are not felt to be necessary. I expect that the first drawdown will be successful although there may be some experimentation to develop the most effective procedure.

I would have no objections to a small-scale experimental project to lessen the risk if it was felt to be necessary. Undoubtedly, objections would be raised to an extra expense with very little improved lake bottom acreage to show for it.

4. The problem with drawing down the lake to 58 feet MSL is that the top of the muck only is exposed. As you state, draining below 58 feet would increase the self-weight compaction. It was my contention that with the quartering system, it would be possible to drain the lake lower than 58 feet MSL and produce a better crust.

Maintaining lake level at 58 feet during the dry-out period will limit consolidation and greatly lower the probability of success. If $20 million is going to be spent on a project such as this, it ought to have a very high probability of success.

I did not think that a very large volume of muck would go to the muck farmers but I am surprised that they do not want fresh material. It would not have to be pumped directly from the lake but could be dewatered prior to use.

5. With a drawdown below 58 feet MSL and with better crust formation, mechanical harvesting of vegetation might be worth considering. Chemical treatment may be another option worth considering, although a careful study of potential effects on water quality would be required.

6-7. I am not familiar with the Farmer's Dike but I assumed that with careful dike placement, irrigation water could be obtained with only piping modifications for both muck farmers and citrus groves.

8. a) The dike specificaitons of 50 foot width on top and 10:1 slope seem unreasonable. This is a key factor in the cost evaluation, and you may wish to retain a geotechnical firm with dredging experience to prepare more accurate estimates.

b) I still feel this $1,900,000 can be deleted as mentioned in No. 1.

c) This appears high but have not studied it further.

d) Although I do not believe we are talking about the same thing, some funds will be needed for water level control.

e) Agree.

f) This would not be necessary as I understand it.

g-h) I would delete these items also.

i) Hopefully most of this could be avoided.

j) Agree.

k) I do not know enough about this to evaluate it but $3,000,000 offers a lot of incentive for improvement.

l) Same as (i).

m) Okay.

n) Okay.

o) Same as (h)

p-q) Figures are questionable.

r) Okay.

s) Okay.

I appreciate the consideration that you have given to my proposal. I believe that the main points of disagreement are:

1. The size and cost of the dikes.
2. The minimum drawdown level possible.
3. The need for a sedimentation basin.
4. Facilities required for muck farm and citrus grove protection.

Should my logic be acceptable, the price would be much lower. However, if the cost of the RSB&W plan and my proposal are still considered to cost $20 million+ I would suggest that we go back to the drawing board and come up with an acceptable process with a reasonable price tag.

Sincerely,

BROMWELL ENGINEERING

Neil R. Greenwood

Neil R. Greenwood, P. E.

NRG:se

TWIN TOWERS OFFICE BUILDING
2600 BLAIR STONE ROAD
TALLAHASSEE, FLORIDA 32301

BOB GRAHAM
GOVERNOR

JACOB D. VARN
SECRETARY

STATE OF FLORIDA
**DEPARTMENT OF ENVIRONMENTAL REGULATION**

Mr. Neil R. Greenwood, P.E.
Bromwell Engineering
202 Lake Mariam Drive
Lakeland, Florida 33803

Dear Mr. Greenwood:

Thank you for your letter of May 30, 1979. The following responses are numbered to correspond with your letter:

1. Your plan uses the remaining three-fourths of the lake as the settling basin for the drawn down section. There presently exists an approximately 1.5-foot thick layer of floc above the bottom muck. In order to consolidate the bottom muck in a limited time period, this floc layer has to be removed. As you are aware, the limited time period is due to frost/freeze protection required by the citrus growers. Therefore, using the remaining three-fourths of the lake as a settling basin will virtually keep all the floc in the lake. Consequently, the floc, which can effectively block the sunlight from the lake bottom, would preclude the growth of rooted aquatic vegetation. Since one of the main purposes of consolidating muck is to encourage the growth of rooted aquatic vegetation in order to compete with algae for nutrients, this would be a major obstacle to the feasibility of the restoration approach outlined in your letter.

2. Since the frost/freeze protection afforded by the lake is a function of its surface area, keeping the water in the sections next to the citrus groves and drawing down the other sections will still significantly reduce the moderating effect of the lake.

3. Lake Apopka has several deep holes, and deep-hole channels are required to convey water from deep holes to pumps. The proposal outlined in your letter of May 30 saves the cost of the sedimentation basin at the expense of the floc problem and a very expensive in-lake pumping station or an extensive deep-hole channel.

4. In order to drain a lake section lower than 58 feet MSL in your quartering system, it is necessary to pump the muck from one section to another. According to your proposal, a layer of soft muck and suspended floc above the consolidated muck would still be present at the completion of this project. This cannot be considered a beneficial end product of successful lake restoration.

5 - 7. I believe my letter of May 10 and the previous explanation has answered these points.

8a) The dike specifications of 50-foot top width, 10:1 slope and 5-foot freeboard are the recommended minimum dimensions suggested by the U.S. Army Corps of Engineers and several experienced dredging contractors. During my cost estimation of your proposal, I did not include the additional cost of removing bottom muck, which should be pumped to at least 1000 feet anyway, prior to the construction of the dike.

The "accurate" estimation from a geotechnical firm is based on the soil test. This office does not have the budget for such tests. Our understanding of the soil in the project area is based on:

A. "Soil Survey of Lake County Area, Florida, by USDA, SCS, 1975";

B. "Water Resources of Orange County, Florida, by USGS, 1968"; and

C. "Appraisal of Water Resources in the East Central Florida Region, USGS, 1972."

b) As explained in Item 3

c to s) There is not much to comment about; after all, they represent just a small portion of total cost.

Thank you again for your suggestions and ideas.

Sincerely,

Erwin Y. Liang

Erwin Y. Liang, P.E.
Water Resources Restoration
and Preservation Section

EYL:ba

# Dredging

*Lake Improvement Association, Inc.*

LAKE COUNTY, FLORIDA

October 9, 1978

D.E.R.

OCT 13 1978

SOUTHWEST DISTRICT

TAMPA

Ms Suzanne P. Walker, Field Project Director
State of Florida, DER, Southwest District
7601 Highway 301 North,
Tampa, Florida 33610

Dear Ms. Walker: Re: Citizen's Review Com on Lake Apopka EIS

Thank you for the 7/13/77 U. S. Geological Survey to review.

Your July 27, 1978 letter enclosed Alternatives and Their Effects - one of which was Dredging. This two page report indicates 222 million m$^3$ of muck that would be removed from the lake at an approximate cost of $127 million.

Funding for this Lake Apopka Restoration Project under current economic philosophy looks improbable to me.

The lake restoration is urgently needed. However, LIA members and guests at its October 5, 1978 meeting passed a resolution committing our group to urge further exploration of the Dredging Concept.

Facts and Considerations:

1. The feasability of methane gas extraction is being explored.
2. The removal of rough fish by haul-seine at the current water level is urged as soon as possible. Contact Jerry Mets, Nesbitt Fish House, Clewiston, Fl.
3. Muck removal would increase the water capacity in the lake.
4. Muck farms lose 1"/year of planting surface by evaporation. (Prospects for muck consumption).
5. Removing the muck removes the need for future drawdowns.
6. If the private sector dredge capital can be generated - give them the muck for disposal against dredging costs.
   Please contact Jack R. Howalt, Dredging Seminar Coordinator, sponsored jointly by Corps of Engrs, DNR, DER and FGFWFC July 9-12, 1978 at the Carillon Hotel, Miami Beach, Fl.
7. Solicit expertise about this concept from:
   a. Dr. Charles Conover, Director, Apopka Research Center, IFAS, Ornamental Horticulture, Rt 3, Box 580, Apopka, Fl 32703 (305/889-4161)
   b. Dr. C. H. Van Middelen, State Chemist, Dept. of Agriculture, Mayo Bldg. Tallahassee, Fl. 32304
   c. Terry Hursh, Oxford Peet Co. Hgwy 466, Oxford, Florida.
   d. Mr. Ferre, Maule Industries, Inc. 100 Bisquaine Blvd. Miami, Fl.

Florida has a commission Staff to promote Florida Citrus. Increase or expand its function to explore the marketability of "muck from Florida". Their assignment would require marketing 1.25 million railroad boxcars filled to handling capacity of Lake Apopka muck. Many other lakes in Florida also contain muck.

Yours very sincerely,

C. E. Heppberger, President
511 Lake Shore Drive,
Leesburg, Florida 32748

cc Sheet Attached

Reproduced from best available copy.

*Lake Improvement Association, Inc.*
LAKE COUNTY, FLORIDA

October 9, 1978

Ms.Suzanne P. Walker, Field Project Director
State of Florida, DER, Southwest District
7601 Highway 301 North,
Tampa, Florida 33610

Page Two Re: Citizen's Review Com on Lake Apopka EIS

cc Board of Lake County Commissioners, 315 W. Main Street, Tavares, Fl 32778

cc Mr. Joe E. Hill, Lake County Pollution Control Board,
324 Ruby Street, Tavares, Fl. 32778

Mr. Louis Polatty, CCE, Exec. VP, Florida Chamber of Commerce,
P. O. Box 5497, Tallahassee, Fl. 32301 904/222-2831

cc Executive Director, Orlando Chamber of Cammerce, 75 E. Ivanhoe Blvd,
Orlando, Fl. 32802

cc Robert Dunbar, Director, Lake County Chamber of Commerce, P. O. Drawer AZ,
Eustis, Florida 32726

C. E. Heppberger
511 Lake Shore Drive,
Leesburg, Fl. 32748

D.E.R.
OCT 13 1978
SOUTHWEST DISTRICT
TAMPA

November 9, 1978

C.E. Heppberger, President
Lake Improvement Association, Inc.
511 Lake Shore Drive
Leesburg, Florida 32748

Dear Mr. Heppberger,

Your letter of October 9, 1978, to Suzanne Walker has been referred to me for response. As you know, we have grave reservations concerning the feasibility of dredging as a restorative technique for Lake Apopka. Our objections to dredging are manifold but are dominated by (1) the great cost involved, (2) the threat of environmental damage, and (3) the length of time required for the dredging process. I hope that the remainder of this letter will explain, in sufficient detail, our reasons for not recommending dredging as a restoration technique for Lake Apopka.

In our EIS we have evaluated several means of restoring lakes. Of those techniques examined, only dredging and drawdown appeared to offer the results required for this particular restoration project (viz, elimination of the smothering effect of muck and reduction of in-lake nutrient loading). We recommend drawdown over dredging because it poses a lesser threat to the environment of the Oklawaha Chain of Lakes and, at an estimated cost of 14 million dollars, constitutes a smaller demand on the pocketbook of the taxpayer.

There are 222,000,000 cubic meters (290,000,000 cubic yards) of muck at the bottom of Lake Apopka. Using a rate of $0.57 per cubic meter, we estimated that the dredging of Lake Apopka would cost $127,000,000 (not including the expense of spoils disposal). It should be noted that this rate ($0.57 per cubic meter) is the cheapest process available and provides no protection to the downstream lakes from increased turbidity, oxygen depletion or increased nutrient release during the dredging process. Because of the danger to the environment, this process is clearly unacceptable, regardless of its costs.

Mr. Carl Klauck, president of Organic Recycling International, recently wrote us concerning a commercial use for the dredged muck. In his letter he mentioned a dredging process that would not cause the environmental damage described above. If this process were found to be environmentally sound it would be acceptable to us as a possible restoration technique. However, the cost of his process was stated to be $3.00 to $3.50 per cubic yard. With 290,000,000 cubic yards, the cost of restoration via dredging would be well over $600,000,000 (actually $870,000,000

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to $1,015,000,000). Again, the cost of spoils disposal is not included in this estimate.

Mr. Klauck, in his letter, and you, in your letter, have indicated that it might be possible to offset the cost of dredging, or even make a profit, by selling the spoils or its by-products. If such a plan were implemented, there would, of course, be an additional cost (or investment) for the handling, processing, packaging and transport of the dredged spoils and by-products.

As reported in our EIS, we have investigated the possiblity of using the organic spoils to produce natural gas which can, in turn, be sold. To this end, a meeting took place in Tallahassee between representatives of Florida Gas Corporation and Ms. Jean Tolman of DER. At this meeting three problem areas were indicated as reported in the EIS. Two, if not all three, of these problems would be applicable to any attempt at uniting private enterprise with the restoration project.

(1) One of the greatest expenses of a business is the capital outlay for the initial construction of facilities. Naturally, it would be poor planning to spend large sums of money to build facilities large enough to process all of the raw material (muck) in a given area within only one or two years. A profit-oriented enterprise would insist on minimizing its capital outlay by reducing the size of its facilities and stretching its operations over a longer period of time. There is a point at which a certain initial capital outlay and the associated operating costs generate an optimal profit; and, it is this point that determines the size of the facility and the length of time it must operate to use up the entire supply of raw material. Representatives of Florida Gas Corporation estimated that they would require at least 15 years; Mr. Klauck suggested that his project would last 20 years. We cannot consider these periods of time, especially with the disruptive process of dredging, as suitable for a restoration project. For the sake of the lake, the residents around the lake, and the entire ecosystem of the Oklawaha Chain of Lakes, we must think of a project duration in terms of only one or two years.

It has been suggested that larger facilities might be built and that other organic wastes, such as orange pulp, muck farm wastes and muck from other nearby lakes, could be processed when Apopka's supply of muck is depleted. This plan would allow for acceleration of the restoration aspect of the process and also provide for long-lived business. However, the fact that such facilities do not presently exist in the area at the required scale of production may suggest that such a process is not economically feasible.

(2) The cost of dredging is not merely a function of the amount of muck dredged, but also a function of the area over which that muck is

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spread. Representatives of Florida Gas Corporation have indicated that in order for their process to be profitable, only the deep holes of muck could be mined, allowing the dredges to remain in the same location for long periods. This would result in little bottom restoration nearshore where it is most needed.

It has been suggested that the state of Florida subsidize the cost of dredging for a period of time, until the private enterprise gets started (say for one year). The dredging cost has been estimated at $870,000,000; even if the project is spread over 20 years (which we find unacceptably long) the first year's dredging expense would be $43,500,000. This, again, does not include the initial capital outlay required for water quality protection during the processing of the muck, for construction of processing facilities and for packaging and/or transport of the product. It is unlikely that such a large sum would ever be funded by the state legislature, and, certainly, the 50 percent funding from EPA's Clean Lakes Program would not apply to such a plan.

(3) Finally, with regard to methane gas extraction from the muck of Lake Apopka, technology has not yet reached the stage where gasification is profitable. Representatives of Florida Gas Corporation have stated that they would need a minimum of five years of research before they could start using dredged materials on a massive scale.

In answer to other points brought up in your letter:

(1) We do encourage the removal of rough fish from Lake Apopka and have tentative plans to do so during the proposed drawdown. However, it should be noted that, as a means of removing nutrients from the lake, fish harvesting is not very effective. For every 1000 pounds of fish harvested, only 14 pounds of nitrogen and 7 pounds of phosphorus are removed from the lake. In 1976, Florida Game and Freshwater Fish Commission estimated the standing crop of fish in Lake Apopka at 2,500,000 pounds. Thus, harvesting of all fish would remove only 35,000 pounds of nitrogen and 17,500 pounds of phosphorus. Rain, falling on Lake Apopka's surface (not including runoff from surrounding land), contributes an average of 1937 pounds of nitrogen and 484 pounds of phosphorus per day. Thus removal of all fish from Lake Apopka is roughly equivalent to the amount of nutrients put into the lake by rainfall alone for 1[illegible] days for nitrogen and 35 days for phosphorus.

(2) Muck removal would, as you say, increase the water capacity of the lake. This increase would be of decided value since it would also raise the heat capacity of the lake, thus providing additional frost/freeze protection for citrus groves to the south. However, drawdown, with muck consolidation, will also increase the water

capacity of the lake. Compaction of the muck will result in a 13 percent increase in lake volume. This will provide a 5 to 10 percent increase in heat capacity.

(3) Muck farms do lose a layer of soil each year due to oxidation. However, the muck dredged from the bottom of Lake Apopka is not equivalent to the soil used on the farms. Conversations with various muck farmers have indicated that the muck would have to be processed (spread and dried while continuously plowed so as not to consolidate) before it could be utilized. This processing could be very expensive and the farmers are not currently willing to pay for it. Any attempt to put dredged muck directly onto existing farms would ruin existing irrigation systems.

(4) Removing the muck does not necessarily remove the need for future drawdowns. By their nature, lakes are only temporary structures and have short life spans relative to other geological structures. It is the natural fate of all lakes to be filled with silt washed in from upstream water sources, runoff from surrounding land, and by debris from dying aquatic vegetation. However, this natural process takes many hundreds, even thousands, of years to occur (if man does not hurry it along with certain types of activities).

Drawdown, with muck consolidation, effectively removes the muck from the system much the same way that dredging does. Although the muck is present, it is in a different form and reacts differently. It releases its nutrients at a decreased rate, it no longer flows or smothers bottom organisms, and it will function as a suitable base for rooted aquatic vegetation. Consolidation produces a permanent irreversable physical change in the muck. The much publicized second drawdown of Lake Tohopekaliga is not due to a deterioration of the consolidated muck but due to a predictable reduction in the much desired game fish population and to new muck created via unabated pollution inputs. (A primary thrust of the Lake Apopka restoration effort has been to abate pollution sources before restoration.)

In conclusion, dredging can be extremely damaging to the aquatic environment. The cost of avoiding such damage brings the dredging expenses towards astronomical figures. With our current technology, the costs of obtaining, handling and processing the muck make commercial use of the muck infeasible. In addition, the efficient commercial use of this muck would require that the dredging process be drawn out over an unacceptably long period of time.

In light of our ever-increasing energy needs, we are very much aware that the organic sediments at the bottom of Lake Apopka may be considered a "misplaced energy resource." Our decision to not utilize this resource at this time does not mean that we are discarding a valuable resource

A drawdown will not change the value of the organic sediment, but merely stabilize it. When technology advances to the point that the muck can be economically obtained and utilized, it will still be at the bottom of Lake Apopka, waiting to serve man.

Sincerely,

Glenn Lukos, Environmental Specialist
Water Resources Restoration and
Preservation Section

GL/nr

cc: Suzanne Walker
Board of Lake County Commissioners
Mr. Joe E. Hill, Lake Co. Pollution Control Board
Mr. Louis Polatty, CCE, Executive VP, Florida Chamber of Commerce
Executive Director, Orlando Chamber of Commerce
Robert Dunbar, Director, Lake County Chamber of Commerce

*A note from . . .*

Vi and/or Chet Heppberger
511 Lake Shore Dr.
Leesburg, Fla. 32748
Phone (904) 787-7515

3-13-79

Dept. Of E
RECEIVED
MAR 27 1979
OFFICE OF SECRETARY

Dear Mr Varn and Staff
Dept of Env. Reg.
Tallahassee Fl

The attached is a self explanatory. I have recommended the proposed Lake Apopka drawdown be postponed until alternate restoration is explored. Perhaps Jack Pike & I can create private capital for the project.

Good cheer

C.K. Heppberger

Reproduced from best available copy.

January 3, 1979

Govenor Robert Graham
Director, Dept. of Environmental Regulation
Senator Vince Fechtel
Rep. Everett Kelly
Rep. Robert Brantley
Rep. Richard Kelly

Gentlemen: Re: Lake Apopka Restoration

We taxpayers urge serious consideration of our comments which follow.

President Carter pleaded for spending restraints on the Federal level before a TV audience a few weeks ago. We assume the Proposition 13 concept will influence an austerity program at the State of Florida level.

The Dept. of Environmental Regulation personnel (DER) are seeking funds to restore Lake Apopka by drawdown at $7 million dollars (State funding) and $7 million dollars Federal funding. History of funding for such projects dictates a cost overrun is likely and more funding sought.

We feel the project leaders will seek a pollution variance while Lake Apopka water is flushed into the Oklawaha Chain of Lakes. This displeases us.

Lake Apopka has been abused for over twenty years. It is our plea that the dredging of muck from tha lake be purmued if it takes more than twenty years using private capital.

Subscribers to this concept:

Albert K. Buse – P.O. Box 547 – Tavares, Fla.
Ronald O Hess P.O. Box 547 Tavares Fla.
Clint Lear – P.O. Box 547 Tavares Fla.
John Hellbig – P.O. Box 547 Tavares, Fla
Stephen D. Perkins P.O. Box 547 Tavares, Fla.
Virgil Buse P.O Box 547 Tavares. Fla
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| Jo Hammond | |

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RECEIVED
APR 11 1979
Division of
Environmental Programs

April 9, 1979

Mr. C. E. Heppberger
511 Lake Shore Drive
Leesburg, Florida 32748

Dear Mr. Heppberger:

Your letter of March 23, 1979, with attached newsclippings and a petition to the Governor on the subject of Lake Apopka, has been received by the Department of Environmental Regulation.

As you know, the Department has spent the last year analyzing various alternative methods for restoring Lake Apopka. These alternatives included: no action, enhanced fluctuation, chemical sedimentation, nutrient diversion, flushing, aeration, dredging, and sediment consolidation through drawdown. The sections of the Draft Environmental Impact Statement (DEIS) which examined the pros and cons of each alternative were distributed to the EIS Citizens' Review Committee of which you are a member. As you know, the DEIS has concluded that, of the available alternatives for treatment, only dredging and drawdown would produce the required improvement of Apopka's muck bottom. An earlier letter to you from this Department (Glenn Lukos, November 9, 1978, copy attached) described in detail the economic and environmental drawbacks to dredging.

If the dredging alternative were selected despite these problems, there does not appear to be private capital available at this time to finance a dredging project for the restoration of Lake Apopka. In exploring the possibilities of dredging utilizing private capital, the Department staff talked with W. M. Cauthen, representing a subsidiary of Florida Gas, and Carl Klauck, President of Organic Recycling International. Their proposals were also discussed in some detail in the attached letter. In the first instance, the methane-producing process being proposed is still experimental, could not be initiated at Lake Apopka for at least five years, and would have to continue for a number of years. Florida Gas is not prepared to invest the capital for mining the muck in Lake Apopka now, and may never be. In the second instance, Mr. Klauck did not propose or envision that his company would provide the capital outlay for the construction of facilities or for the handling and processing of materials. He intended that these costs as well as the cost of dredging would be handled by the State. The muck farmers have indicated they could utilize the lake's bottom material, as long as the Department performed the dredging and handled the necessary drying

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of the material. No private capital for dredging or spoil handling was ever offered or envisioned. In short, the hope of finding private capital to voluntarily restore Lake Apopka appears unrealistic.

While we appreciate the concerns expressed by the number of people who signed the January 3, 1979, petition, we would like to correct one assumption that was made in the preamble. The petition reads: "We feel the project leaders will seek a pollution variance while Lake Apopka water is flushed into the Oklawaha Chain of Lakes. This displeases us." This was never the intention of the Department. In fact, there is specific language in the contract between DER and the engineering firm of Ross, Saarinen, Bolton and Wilder to ensure that the project design not allow degradation of the downstream waters. The specific language is found in Article III, Design Constraints, and is written as follows: "Water quality in the Oklawaha Chain of Lakes and connecting water courses shall not be degraded below the standards set in Chapter 17-3, Florida Administrative Code, or degraded below existing conditions, whichever is less stringent. It is recognized that some water quality parameters in these waters already exceed allowable limits as specified in Chapter 17-3, Florida Administrative Code." This safeguard is in addition to that provided by the construction of a coffer dam between Lake Eustis and Lake Harris.

As the cover letter in the DEIS states, a public hearing will be conducted in Tavares on April 10, 1979. Your participation in that hearing is encouraged. The purpose of the hearing is to obtain comments from the public on the DEIS and the restoration project in general. When all comments are received, the Final EIS will be written and the Department will reach a decision concerning project implementation.

Thank you for your continued interest in the restoration of Lake Apopka.

Sincerely,

John C. Bottcher, Director
Division of Environmental Programs

JCB:swa

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*A note from . . .*

Vi and/or Chet Heppberger

511 Lake Shore Dr.
Leesburg, Fla. 32748
Phone (904) 787-7515

3/9/[illegible]

Dear Gov Graham

The attached are self-explanatory.

We are not sure the "officials want $67 million for Water Mgt" includes the Lake Apopka Project.

The writer urges delay on the latter project (funding) until Ventra-Vac dredging, Final separation of solids and water and the markets for the muck can be more fully explored — using private capital.

Thank you.

C.E. Heppberger

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April 20, 1979

RECEIVED
APR 25 1979
D. E. R.
Water Resources Management

Mr. and Mrs. C. E. Heppberger
511 Lake Shore Drive
Leesburg, Florida 32748

Dear Mr. and Mrs. Heppberger:

Governor Graham has asked us to respond to your letter of March 9, 1979. It is similar to your letter of March 23 to Secretary Varn which was answered in detail by Mr. John Bottcher of this Department.

The Department of Environmental Regulation is aware of your stance in opposition to the proposed drawdown of Lake Apopka, and your comments to that effect will be included within the Final Environmental Impact Statement on this project.

Because of the inherent high cost of a pumped drawdown and refill, the Department is continuing to explore the possibility of a dredging project to remove the lake's muck for use in commercial endeavors. However, as late as April 17, 1979, Department staff talked with a representative of the Ventra-Vac Company in California and learned that they have not yet discovered a market for the soil that would be removed. We will continue to work with these researchers; however, at the present time, drawdown still appears more feasible than dredging Lake Apopka with private capital. As you probably know, the Lake Apopka project is not in the administration's budget this year, so we can review these issues prior to our next budget submission.

Your continued interest in the Lake Apopka project is appreciated.

Sincerely,

/s/Victoria J. Tschinkel

Victoria J. Tschinkel
Assistant Secretary

VJT/bs

cc: Honorable Bob Graham

# Annelidic Conversion

**ORGANIC RECYCLING INTERNATIONAL, INC.**

P. O. Box 38
Holland Landing, Ontario
LOG1HO (Canada)
Phone (416) 895-3075

P. O. Box 208
Goldenrod,
Florida, 32733
Phone (305) 671-6602

D.E.R.
SEP 18 1978
SOUTHWEST DISTRICT
TAMPA

September 13th, 1978

Mrs. Suzanne P. Walker
Field Project Director
Water Resources Restoration and
Preservation Section
State of Florida
Department of Environmental Regulation
7601 Highway 301 North
Tampa, Florida 33610

Dear Mrs. Walker:

Enclosed you will find a proposal by Organic Recycling International, Inc. in regard to the clean-up of Lake Apopka. Description and figures are typical and subject to refinement.

Some time ago I explained to you that tests with sediments from Lake Apopka were conducted in our Vermiculture Laboratory and revealed an excellent potential for an "Annelidic Conversion" project.

This application will solve completely any disposal problem, even better, it will turn the "misplaced resource" into economical gain, create employment, be effective in pollution control, and last but not least will drastically off-set initial financing.

We are confident that Department of Environmental Regulation decision makers will see the advantages, expecially when it comes to the delicate point of opposition to various techniques for the lake clean-up operation.

Organic Recycling International, Inc. believes in nature's concept combined with progressive management.

Very truly yours,

Carl Klauck

Carl Klauck
President

CK:dc

Enclosures

*"ANNELIDIC CONVERSION . . . CONVERTING WASTE INTO DOLLARS"*

**ORGANIC RECYCLING INTERNATIONAL, INC.**

P. O. Box 38
Holland Landing, Ontario
LOG1HO (Canada)
Phone (416) 895-3075

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Florida, 32733
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DER
SEP 18 1978
SOUTHWEST DISTRICT
TAMPA

## APPLICATION OF THE "VERMICOMPOSTING CONCEPT" FOR THE CLEAN-UP OF ABUSED LAKE APOPKA

The removed material, called muck or sediment, is of biological nature and can be easily cultured with earthworms. These will in turn convert the organic material to an acceptable and valuable soil. Earthworms eat anything that is biodegradable. All of these materials can be recycled to save both money and our natural resources from which they are derived.

The following is a description of the general requirements for "vermicomposting" the sediments from Lake Apopka:

1. Two to three acres off-shore at any suitable and available location.
   Cost for rent------------------------------------$ 10,000.00
2. Facilities: Simple, open sided, construction to protect against excess sunshine and rain.
   Cost----------------------------------------------$ 19,400.00
3. Excess water should be filtered or somehow removed from material. (This is Step #1: A separate project; cost estimate needed.)
4. Equipment: Front end loader, various tools, wheelbarrow, water hose, forks and shovels, wooden containers, etc.
   Cost----------------------------------------------$ 20,700.00
5. Worms: For start-up: two tons, stock will increase by reproduction.
   Cost----------------------------------------------$ 8,000.00
6. Administration: One Project Supervisor (annual)-$ 20,000.00
   One Secretary (annual)----------------------------$ 11,000.00
7. Manpower: Four men for labor ($48,000).
   One Foreman ($15,000).
   Cost----------------------------------------------$ 63,000.00
8. Miscellaneous: one small trailer (mobile) for office use; office equipment, utilities, etc.
   Cost----------------------------------------------$ 10,300.00

TOTAL COST-------------------------------------------$162,400.00

"ANNELIDIC CONVERSION . . . CONVERTING WASTE INTO DOLLARS"

"Organic Recycling International, Inc." (O.R.I.) has information that a California firm has a proven method which can be utilized to dredge Lake Apopka efficiently without a draw-down.

In a typical dredging installation, a 15 foot unit with 200 CFM going through it is developing 3 PSI negative pressure due to the suction caused by the venturi effect. This means that the compressor is having to develop less pressure to push the same amount of air through the tube. In fact, the horsepower savings in this case amount to a whopping 32%. Taller units are even more efficient.

1. Dredging can be carried out for an estimated cost of $3.00 to $3.50 per cubic yard, based on our present information.
2. A guaranteed production of 2,500 cubic yards per day minimum, when a working depth of 15 feet or more can be maintained. Also working at a depth of 6 feet is possible.
3. A patented air lift suction principle for dredging, so that solids contents are high, yet no turbulence is created in the working area.
4. Contractor produces his own in-line treatment system so that the water of the lake is never degraded in quality, and all water returned to the lake is as clean as that in the lake. A guarantee to meet EPA regulations on all contracts.
5. The system requires approximately two acres on-shore area to set up water treatment equipment and service yard. After dewatering process, materials stockpiled by use of conveyor belts for later processing.

O.R.I. also has access to a technique which can extract methane gas out of the sediment off-shore before "vermicomposting". If included this would be a separate "in-line" project.

O.R.I. will do the marketing of the worm castings and part of the revenue after all operation costs have been covered, will be returned to offset substantially the cost of the financing. First payment should start at the beginning of the second year.

The recycling project once established should be a permanent institution and continue after the sediments from Lake Apopka are all used up. Local sources of raw materials will always be available: Sludge from Waste Water Treatment Plants and food, vegetable and fruit processors including solid (organic) waste from household garbage. Therefore, over a period of 20 years many millions of dollars could be repaid.

October 19, 1978

Mr. Carl Klauck, President
Organic Recycling International, Inc.
P.O. Box 208
Goldenrod, Florida 32733

Dear Mr. Klauck:

Your letter of September 13, 1978, to Suzanne Walker was referred to me for response. I apologize for the delay, but I have taken some time to research my answers. I am sure that Lake Apopka sediment, with its high organic content, would have excellent potential for your "Annelidic Conversion" process. I also agree that utilization of a "misplaced resource" is desirable but, in this case, only as a secondary concern. Our primary objective is the restoration of Lake Apopka; your proposal does not appear to meet this objective.

BACKGROUND:

Lake Apopka, with a surface area of 31,000 acres and an average depth of 5 feet, has 155,000 acre-feet of muck on its bottom. This translates to well over 200,000,000 cubic yards of muck, much of which would have to be removed or otherwise stabilized to improve Lake Apopka's water quality.

POINTS OF CONCERN IN ANNELIDIC CONVERSION PROPOSAL:

1. At your estimated dredging rate of 2500 cubic yards per day this process would take well over 200 years to remove the muck currently present. (In addition, I suspect that this dredging rate is close to the rate at which muck is currently accumulating.) It is generally accepted that water quality parameters do not improve during the dredging process. Increased turbidity and release of nutrients contribute to decreased water quality. Thus, a 200-year dredging project cannot be seriously considered as a means of lake restoration.

2. Your total cost estimate for the project ($162,400) does not include the cost of dredging. At $3 per cubic yard and 2500 cubic yards per day, this cost comes to $7500 per day or $2,700,000 per year, or

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well over $600,000,000 for the entire project. In addition, your proposal does not include a cost estimate for an "in-line treatment system" to return only clean water to the lake. It was the solution to this very problem that eventually added $9,000,000 to the cost of the proposed drawdown project. Also, many of the expenses listed, particularly labor expenses, are given for one year only, not your estimated 20-year project life or our 200-year estimate. Thus, when these added expenses are considered, the cost of your proposal does not compare favorably with the cost of the proposed drawdown.

3. With an on-land working area of only 2 acres and a dredging rate of 2500 cubic yards per day, only one month of dredging will cover the entire working area with 7.8 feet of muck. This leaves no room for operation facilities or for an "in-line treatment system."

4. Finally, I seriously doubt that this proposed project can operate at a self-sustaining level. Considering the costs of labor, dredging and of meeting water quality standards in addition to the initial capital outlay, I doubt that the market would support a product price that would allow for a profit.

In conclusion, we cannot consider your proposal as a viable alternative based on the fact that it does not meet our primary objective (restoration of Lake Apopka) and that, even with a profit-oriented operation, the expenses of your proposal are too great.

Sincerely,

GL

Glenn Lukos
Environmental Specialist
Water Resources Restoration
and Preservation

cc: Suzanne Walker

## Island Building

SEMINOLE WOODS, Inc.

D.E.R.
NOV 8 1978
SOUTHWEST DISTRICT
TAMPA

November 6, 1978

Suzanne P. Walker
Field Project Director
Office of Water Resources
Restoration and Preservation
State of Florida
Department of Environmental Regulation
7601 Highway 301 North
Tampa, Florida

Dear Ms. Walker:

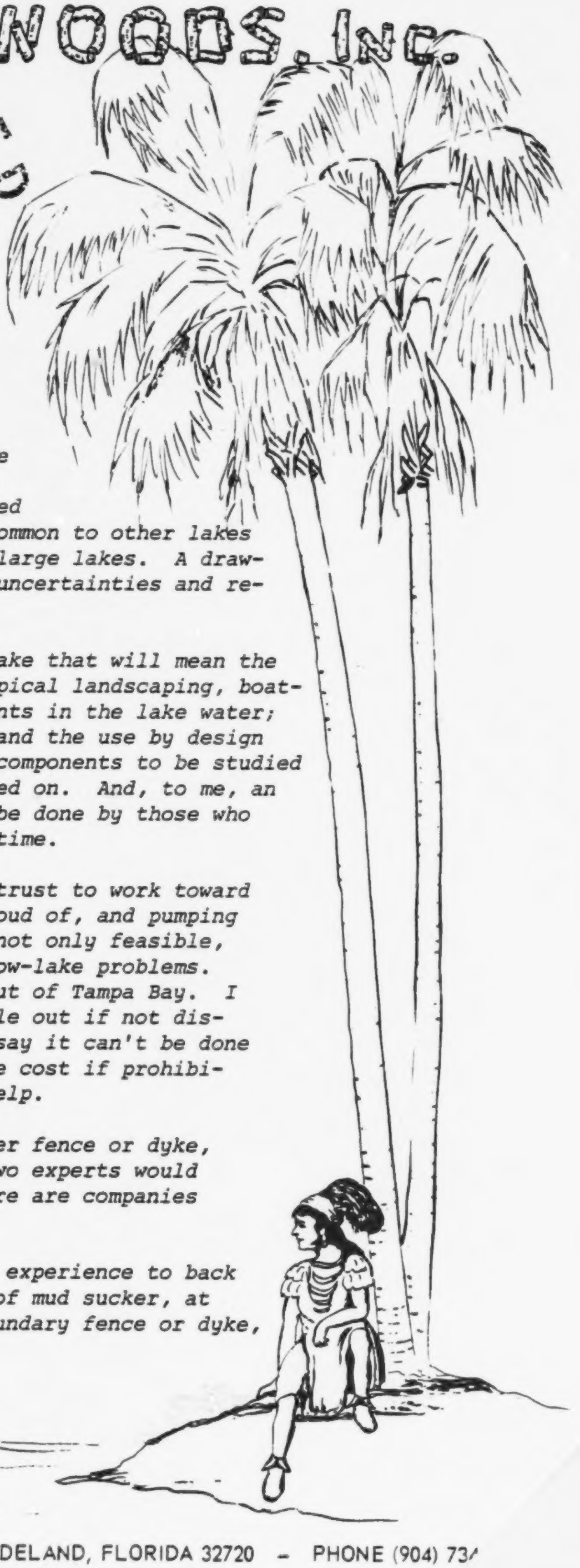
I admired your part in and contribution to the recent hearing in Tavares. However, I feel a more unbiased, sincere effort should be studied along other approaches to what is a problem common to other lakes in Florida. Lake Apopka is one of Florida's large lakes. A draw-down there is a big project froght with many uncertainties and repercussions.

After all, what you want to accomplish is a lake that will mean the most to the people. Aesthetic beauty, subtropical landscaping, boating enjoyment, and safety; movement and currents in the lake water; improvement to the lake's spring or springs, and the use by design of its flow. The above are but a few of the components to be studied and considered before a final course is decided on. And, to me, an important factor is how much of the work can be done by those who need the work and by schools in the vacation time.

I feel it is more in keeping with the public trust to work toward a goal that will ultimately be a job to be proud of, and pumping that mud (muck) up in the form of islands is not only feasible, but is the way other states have solved shallow-lake problems. After all, Davis Island in Tampa was pumped out of Tampa Bay. I am aware that muck is fluid, but it does settle out if not disturbed, and therein lies the key. To flatly say it can't be done sounds superficial to me. And to say that the cost if prohibitive - well, desire and ingenuity sometimes help.

The two critical departments are, (1) perimeter fence or dyke, and (2) the pump and delivery. Probably no two experts would agree on the same equipment; but in Tampa there are companies that do that kind of work in a big way.

I have my own ideas, but I haven't the actual experience to back them up. My choice would be an airlift-type of mud sucker, at least for the initial stabilization of the boundary fence or dyke,



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and probably should be used all the way.

Would it not be in keeping with policies of D.E.R. to get some case data from prairie states like Wisconsin, Iowa, Illinois, Indiana and Ohio? I have been told they have made shallow lakes into deep-water lakes by pumping the mud into islands.

If you dare, just visualize Cypress Gardens enlarged a hundred times.

Sincerely,

T. R. Strawn

P.S. One tranquilizer in this plan - it doesn't have to run on schedule. And the mud doesn't have to flow twenty-four hours a day.

December 5, 1978

Mr. T.R. Strawn
Route 1, Box 395
Deland, Florida 32720

Dear Mr. Strawn,

Thank you for your patience in regard to an answer to your letter of November 6, 1978. In researching background information on your proposal, we talked to (1) representatives of a California dredging company that specializes in airlift dredging, (2) a specialist in community planning from Florida State University, (3) representatives from the engineering firm of Ross, Saarinen, Bolton and Wilder (RSB&W), (4) a representative of Bio-Engineering Sciences, Inc., and (5) a number of in-house specialists.

Like the proposed drawdown, the concept of island-building is quite complex. As a result, I have tried to break our comments into smaller units and have discussed each in an outline format.

A. The littoral zone is generally defined as that portion of a lake in which rooted aquatic plants grow. It is here that nutrients are taken up by the growing plants and essentially removed from the system, if only temporarily. The plants also provide food and habitat for many invertebrates and small fish which, in turn, are eaten by the much desired game fish.

The principle parameter that determines the extent of the littoral zone is the amount of light that is available to the plants. (Like terrestrial plants, aquatic plants require light to live and grow; with insufficient light they die.) In turn, two factors determine how much light reaches the plants:

1. Turbidity. Suspended solids will block light transmission. In Lake Apopka, light transmission is reduced both by the great amount of suspended muck in the water and by the dense concentration of microscopic algae whose growth is promoted by the high nutrient content of the water. As a result, light transmission in Lake Apopka is generally limited to about 11 inches. This may be compared to nearby Lake Harris where light transmission is about 3.5 feet and, on occasion, reaches 6 feet.

2. Water depth. Water, itself, absorbs light; as a result, light becomes extinguished as one descends in a column of water. Thus even in a lake whose water has a high degree of transmission (say 6 feet), deeper portions of that lake (say 10 feet) will not be able to support rooted plant life.

The building of islands is a recognized means of increasing the extent of the littoral zone in a deep-water lake. The sloping shoreline of the newly constructed islands provides shallow areas where rooted aquatic plants may receive enough light to grow. Lake Apopka, like most Florida lakes, is a shallow lake; its diminished littoral zone is caused not by a lack of shallow water, but by the high turbidity of the water. In the 1940's, Lake Apopka's littoral zone covered 80% of the lake. Today, without any major changes in the depth of the lake, the littoral zone covers only 0.03% of the lake. This tremendous reduction of the littoral zone is due to an increase in flocculant muck with a resulting rise in the turbidity, and could not be reversed by island-building.

B. We certainly did not mean to say that island-building cannot be accomplished in Lake Apopka. We do feel, however, that it is infeasible. Our engineers (RSB&W) indicate that the construction of such islands would indeed be possible provided that funds were virtually unlimited and that most regulations governing pollution control were suspended during the project. Your example of Davis Island, in Tampa Bay, is an entirely different situation. The material used for its construction was not a muck similar to that in Lake Apopka, but a sand and shell mixture. In addition, the island was constructed in the 1920's when there were no turbidity standards. There is a current attempt to construct islands in Tampa Bay from spoils dredged during a harbor deepening project. These spoils consist of a flocculant muck, similar to that of Lake Apopka, which has accumulated during the past 60 years. The attached article from the November 27, 1978 Tampa Tribune describes some of the problems this project has run into.

As you stated in your letter, any attempt to contain the muck in a confined area of the lake would require a boundary of some sort, probably sheet piling. An island constructed in such a manner would not have the natural sloping shores, but a straight vertical drop at its edge. This shape defeats the original purpose of island-building, i.e., augmentation of the littoral zone (see part A).

C. The building of islands from muck will require dredging. Our reservations concerning dredging have been voiced many times and are based primarily on two points, cost and environmental damage.

1. Dredging is one of the most environmentally dangerous procedures carried out by man in the aquatic environment. Most dredging methods stir up the bottom sediments, causing increased turbidity. In turn, this causes a decrease in light transmission and a further loss in the littoral zone, not to mention the smothering effects of the sedimentation of suspended solids.

In Lake Apopka, the bottom sediments are supersaturated with nitrogen and phosphorus. Every time the sediment is disturbed by wind action or by motorboat activity, more of these nutrients are released to the water. Dredging will most certainly disturb the bottom sediments, releasing massive amounts of nutrients into the water. The nutrients, in turn, promote the growth of microscopic algae which further reduce light transmission and, when they die, settle to the bottom to form an additional layer of flocculent muck. (The attached article from the November 27, 1978 Tampa Tribune gives examples of many of the damaging effects of dredging.)

2. There are many varieties of dredging methods, each with its advantages and disadvantages. The cheapest method quoted in current literature costs $0.57/cubic yard, but causes extreme environmental damage. Our engineers (RSB&W), in the proposed construction of an in-lake sedimentation basin for the drawdown, quote a cost of $1.25/cubic yard. This method also causes some damage, but can be tolerated because the Apopka-Beauclair Lock and Dam will be closed and Lake Apopka will be isolated from the chain of lakes for the one-month period of dredging. The airlift method you describe is performed by a California company which assures us that the water quality should not be endangered using their method. However, the preliminary estimate given by this company is $3.00 to $3.50/ cubic yard.

Lake Apopka currently has 290,000,000 cubic yards of muck on its bottom. The construction of spoil islands, while clearing the bottom of the lake, would require that more than half of the muck be dredged (say 150,000,000 cubic yards). Thus dredging costs alone for such a project would be between $85,500,000 (at $0.57/cubic yard) and $525,000,000 (at $3.50/cubic yard). The associated costs of confining the dredged muck and procedures for pollution control are not included in these estimates.

D. Island building can only be considered an artificial manipulation of the environment and simulates no known natural function in nature. Such manipulations are often environmentally dangerous because of unforeseen ecological repercussions. Scientific literature has recorded many accounts of such manipulations and the resulting ecological disasters.

Drawdown, on the other hand, simulates a periodic drought, a natural condition for southern lakes. Southern aquatic organisms have evolved to expect, and even require, periodic droughts; thus a drawdown should not cause any ecological repercussions.

I hope that the material presented here has sufficiently explained our position. As one last point, I emphasize that central and southern Florida represent the United States' only sub-tropical region. As a result, we must be very cautious in using any environmental management technique imported from the northern, temperate regions—no matter how successful it is there. Before the study of southern lakes became common, many Florida lakes were damaged, some beyond repair, by the use of northern lake-management techniques. If you have any further comments or questions, please feel free to write or call me at (904)488-9560.

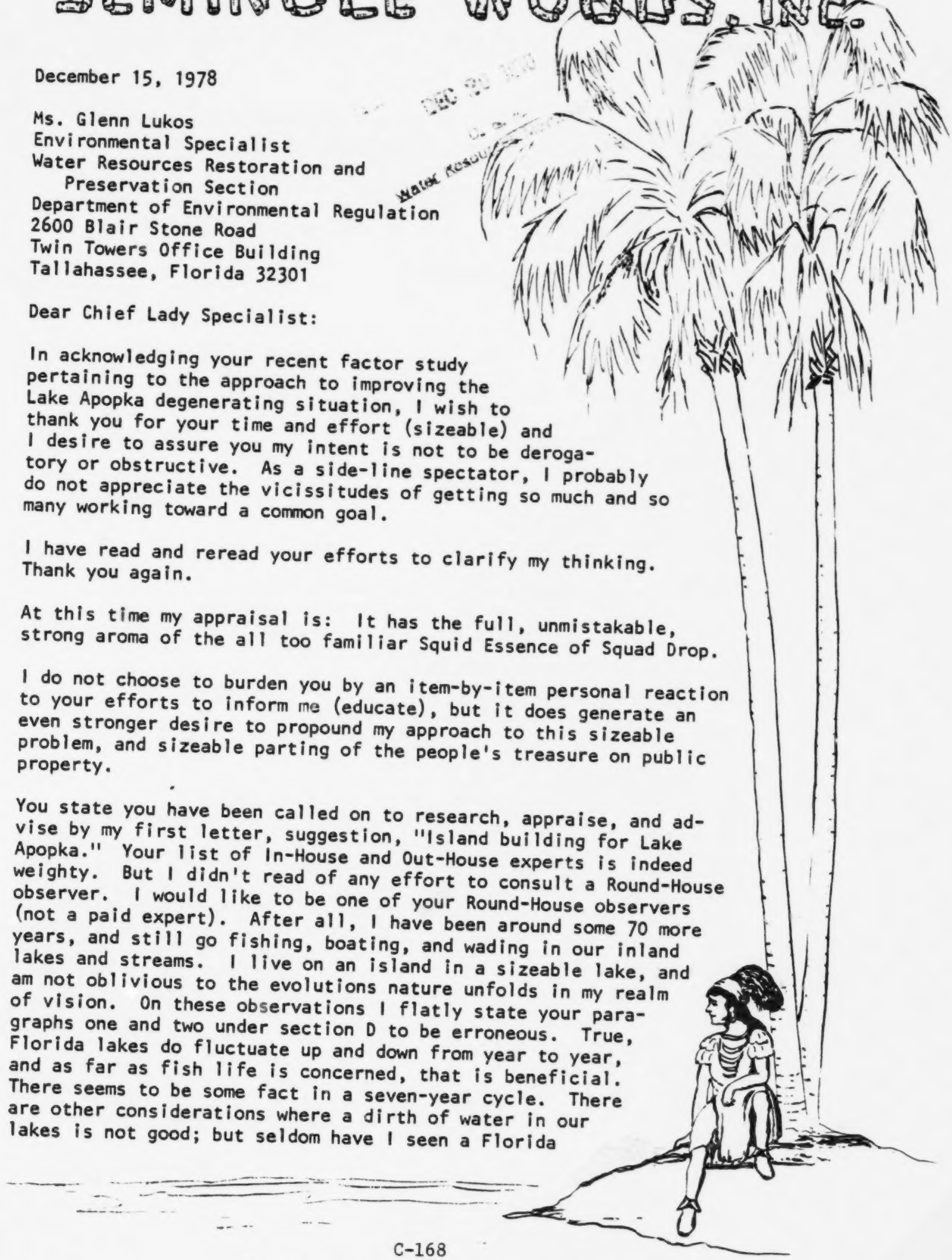
Sincerely,

Glenn Lukos, Environmental Specialist
Water Resources Restoration and
Preservation Section

GL/nr

Attachment

SEMINOLE WOODS, INC.



December 15, 1978

DEC 20 1978
Water Resou[illegible]

Ms. Glenn Lukos
Environmental Specialist
Water Resources Restoration and
Preservation Section
Department of Environmental Regulation
2600 Blair Stone Road
Twin Towers Office Building
Tallahassee, Florida 32301

Dear Chief Lady Specialist:

In acknowledging your recent factor study pertaining to the approach to improving the Lake Apopka degenerating situation, I wish to thank you for your time and effort (sizeable) and I desire to assure you my intent is not to be derogatory or obstructive. As a side-line spectator, I probably do not appreciate the vicissitudes of getting so much and so many working toward a common goal.

I have read and reread your efforts to clarify my thinking. Thank you again.

At this time my appraisal is: It has the full, unmistakable, strong aroma of the all too familiar Squid Essence of Squad Drop.

I do not choose to burden you by an item-by-item personal reaction to your efforts to inform me (educate), but it does generate an even stronger desire to propound my approach to this sizeable problem, and sizeable parting of the people's treasure on public property.

You state you have been called on to research, appraise, and advise by my first letter, suggestion, "Island building for Lake Apopka." Your list of In-House and Out-House experts is indeed weighty. But I didn't read of any effort to consult a Round-House observer. I would like to be one of your Round-House observers (not a paid expert). After all, I have been around some 70 more years, and still go fishing, boating, and wading in our inland lakes and streams. I live on an island in a sizeable lake, and am not oblivious to the evolutions nature unfolds in my realm of vision. On these observations I flatly state your paragraphs one and two under section D to be erroneous. True, Florida lakes do fluctuate up and down from year to year, and as far as fish life is concerned, that is beneficial. There seems to be some fact in a seven-year cycle. There are other considerations where a dirth of water in our lakes is not good; but seldom have I seen a Florida

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lake go as dry as man's instigated draw-down would perscribe. As to nature being engaged in Island Building, I would just have to show.

Madam Specialist, you have a golden opportunity, an awesome responsibility, to turn a disaster situation into a badly needed bonanza. I do not know if you are exposed to the fact that this country is fast generating an avalanche of young Americans. Their exuberance is only matched by an inherent, built-in thrust for adventure. If we fail to make it within their sights, more will look to pot for excitement. It is high time we weigh the facts in this equasion.

The plan that I would like to see tried would engage a lot of young, active, interested bodies, working toward a goal they would point to with pride in after years.

First, I would like to show you lakes where Nature has built and is building islands. Second, if you have not passed the point of no return, could we not pool some common bond of engineering and round-house observations?

Sincerely,

A Round-House Observer

T.R. Strawn

T. R. Strawn

Tel. 904 734-5506

TRS/km

P.S. I feel sure the job can be done for a fraction of the cost you are stating - if my idea works.